TENNESSEE VALLEY AUTHORITY

CHATTANOOGA, TENNESSEE 37401

5N 157B Lookout Place

December 16, 1985

Director of Nuclear Reactor Regulation
Attention: Mr. B. J. Youngblood, Project Director
PWR Project Directorate No. 4
Division of Pressurized Water Reactor (PWR)
Licensing A
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Youngblood:

In the Matter of the Application of	)	Docket Nos. 50-390
Tennessee Valley Authority	)	50-391

Please refer to R. H. Shell's letter to E. Adensam dated November 19, 1985 concerning an additional diesel generator unit (ADGU) at the Watts Bar Nuclear Plant (WBN).

The letter committed to provide NRC with FSAR and technical specification changes for the ADGU in order to enable NRC to complete the necessary licensing reviews to permit ADGU operability by unit 1 fuel load. Enclosure 1 is the technical specification changes with justification and enclosure 2 is the FSAR changes. The FSAR changes will be included in Amendment 58 to the WBN FSAR which is scheduled to be submitted by the end of January 1986.

The timeliness of this submittal has been previously discussed with Tom Kenyon of your staff.

If there are any questions, please get in touch with K. P. Parr at FTS 858-2680.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

J. W. Hufham

J. W. Hufham
Manager of Licensing

8512200037 851216
PDR ADOCK 05000390
A PDR

Sworn to and subscribed before me
this 16th day of Dec, 1985

Paulette H. White
Notary Public
My Commission Expires 8-24-88

Enclosures
cc: U.S. Nuclear Regulatory Commission (Enclosures)
Region II
Attention: Dr. J. Nelson Grace, Regional Administrator
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30323

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Justification for Technical Specification Changes

Background

As currently designed, all four diesel generators are required to satisfy the licensing design basis accidents while assuming a single failure. When any one of the four trained diesel generators (1A-A, 2A-A, 1B-B, 2B-B) is declared inoperable, the ACTION statements of Limiting Condition for Operation (LCO) 3.8.1.1 allow only 72 hours to return all diesel generators to operability. This time constraint limits the magnitude of any maintenance and/or repair that can be completed while either nuclear unit is at power. Operating experience at TVA's Sequoyah Nuclear Plant has indicated there is a significant probability of exceeding this 72-hour limit and incurring the cost of lost production due to a forced unit shutdown. The addition of the C-S diesel generator will preclude this loss of production by providing an alternate which can be substituted for any trained diesel generator. Also, the substitution of a program of demonstrated diesel generator reliability for a reduction in the frequency of fast starts required by technical specifications will reduce the probability of having a diesel generator inoperable.

Justification

The attached technical specification changes will allow the substitution of the C-S diesel generator set for any one of the trained diesel generator sets.

The following LCOs have been modified to ensure operability of necessary subsystems when the C-S diesel generator is required:

3.8.1.1	AC Power Sources, Modes, 1, 2, 3, 4
3.8.1.2	AC Power Sources, Modes 5, 6
3.7.11.2	Fire Protection
3.7.11.4	Hose Stations
3.8.4.2	Thermal Overload Bypass Devices
3.7.13	Area Temperature Monitoring

LCO 3.3.3.7, "Fire Detection Instrumentation," has already been changed to include the fire and smoke detectors in the additional diesel generator building.

The surveillance requirements associated with these LCOs have been divided into two categories, those required to be performed regularly and those performed only when the C-S diesel generator is replacing another diesel generator. The following surveillance requirements will be performed on a regular schedule to demonstrate the availability of the C-S diesel generator to be substituted for one of the other diesel generators:

4.3.3.7.1, 4.3.3.7.2, 4.3.3.7.3	Fire Detection Instrumentation
4.7.11.1, 4.7.11.2, 4.7.11.4	Fire Protection
4.8.1.1.2.a.1, 2, 3	Diesel Generator Testing
4.8.1.1.2.b through h	Diesel Generator Testing
4.8.1.1.3, 4.8.1.1.4	Diesel Generator Testing

Failure of one of these surveillance requirements when the C-S diesel generator is not being used to satisfy LCO 3.8.1.1 or 3.8.1.2 only renders the C-S diesel generator unavailable to be substituted. The operability of the emergency AC power system will not be affected. Surveillance requirements 4.8.1.1.2.a.4, 5, and 6, and 4.7.13 will be used to demonstrate the operability of the C-S diesel generator when it is substituted for one of the trained diesel generators. Also, surveillance requirement 4.8.4.2 will be performed on the C-S diesel generator essential raw cooling water supply valves (1-FCV-67-72 and 2-FCV-67-73) when the C-S diesel generator is substituted for one of the other diesel generators. The bypass of the thermal overload devices for these valves uses the components from whichever diesel generator the C-S diesel generator is replacing; therefore, performing this test for the other diesel generators verifies the operability of the thermal overload bypasses for valves 1-FCV-67-72 and 2-FCV-67-73.

Also included in this proposal are changes required to implement a diesel generator reliability improvement program in accordance with the recommendations of Generic Letter 84-15. These changes substitute a program of demonstrated diesel generator reliability for a reduction in the frequency of fast starts required by technical specifications. One change which differs from the example presented in Generic Letter 84-15 is in Table 4.8-1. The generic letter has a requirement to declare the diesel generator inoperable when there have been 5 failures in 20 valid tests or 11 failures in 100 valid tests. The reliability action then requires the performance of a requalification test on the diesel generator. The requalification test assumes the diesel generator is operable but no criteria has been provided to determine operability before starting the test. The requirement to declare the diesel generator inoperable before performing the requalification test is confusing and the criteria specified in the requalification test is sufficient for declaring the diesel generator inoperable and requiring the plant to shutdown. Also, included is a new action statement to address inoperability of a diesel generator due solely to low fuel tank levels. The increased time limit will allow a reasonable amount of time to test fuel oil in the yard storage tank before transfer to the diesel generator fuel tanks. The requirement to start all diesel generators does not give added assurance that low fuel levels will not hamper their performance. The required engine start will use up remaining fuel oil which may be needed during a loss of offsite power.

This program for reducing the number of unnecessary diesel engine starts and allowing sufficient time to perform vendor-prescribed preparations before a diesel engine start will reduce the wear on components and increase diesel generator reliability. The proposed technical specification changes do not require the C-S diesel generator to be available at all times; therefore, it cannot be relied upon to mitigate the consequences of a loss of offsite power. However, realistically with the C-S diesel generator available and increased diesel generator reliability, the probability of a prolonged loss of all AC power will decrease.

SPRAY AND/OR SPRINKLER SYSTEMS

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LIMITING CONDITION FOR OPERATION

3.7.11.2 The following Spray and/or Sprinkler Systems shall be OPERABLE:

a. Reactor building - RC pump area, Annulus;

b. Auxiliary building - Elev. 692, 713, 729, 737, 757, 772, 782, ABGTS Filters, EGTS Filters, Purge Filters, 125 V Battery Rooms;

c. Control building - Elev. 692, Cable spreading room, MCR air filters and Operator living area;

d. Diesel building - Corridor area;

e. Turbine building - Control building wall; and

f. ERCW pumping station (Intake). Insert g.

g.

APPLICABILITY: Whenever equipment protected by the Spray/Sprinkler System is required to be OPERABLE.

ACTION:

a. With one or more of the above required Spray and/or Sprinkler Systems inoperable, within 1 hour establish a continuous fire watch with backup fire suppression equipment for those areas in which redundant systems or components could be damaged; for other areas, establish an hourly fire watch patrol.

b. The provisions of Specifications 3.0.3 and 3.0.4 are not applicable.

SURVEILLANCE REQUIREMENTS

4.7.11.2 Each of the above required Spray and/or Sprinkler Systems shall be demonstrated OPERABLE:

a. At least once per 31 days by verifying that each testable valve (manual, power-operated, or automatic) in the flow path is in its correct position,

b. At least once per 12 months by cycling each non-self indicating testable valve (accessible during plant operations) in the flow path through at least one complete cycle of full travel,

g. Additional Diesel Building — Pipe gallery, diesel generator, fuel oil pump, transformer, switchgear, and electrical board rooms.

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TABLE 3.7-3 (Continued)

FIRE HOSE STATIONS

LOCATION	ELEVATION	HOSE RACK #
Intake Pumping Station (ERCW)		
Electrical Board Rm.	716	0-26-595
Electrical Board Rm.	716	0-26-596
B Strainer Room	727	0-26-594
A Strainer Room	727	0-26-597
A Fire Pump Room	747	0-26-1710
B Fire Pump Room	747	0-26-1711
Additional Diesel Generator Building		
Top of stairway	765	0-26-1646
Air Intake room	765	0-26-1647
Air Intake room	765	0-26-1648
Bottom of stairway	742	0-26-1649
Diesel generator room	742	0-26-1650

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TABLE 3.7-4

AREA TEMPERATURE MONITORING

	AREA	TEMPERATURE LIMIT (°F)
1.	Aux Bldg el 772 next to 480V Sd Bd transformer 1A2-A.	≤ 104
2.	Aux Bldg el 772 next to 480V Sd Bd transformer 1B1-B.	≤ 104
3.	Aux Bldg el 772 next to 480V Rx MOV Bd 1A2-A.	≤ 104
4.	Aux Bldg el 772 across from spare 125V vital battery charger 1-S.	≤ 104
5.	Aux Bldg el 772 next to 480V Rx MOV Bd 2A2-A.	≤ 104
6.	Aux Bldg el 772 next to 480V Sd Bd transformer 2A2-A.	≤ 104
7.	Aux Bldg el 772 next to 480V Sd Bd transformer 2B2-B.	≤ 104
8.	Aux Bldg el 772 next to 480V Rx MOV Bd 2B2-B.	≤ 104
9.	Aux Bldg el 772 U1 Mech Equip Room B.	≤ 104
10.	Sd Bd room el 757 U1 behind stairs S-A3.	≤ 104
11.	Sd Bd room el 757 U2 behind stairs S-A13.	≤ 104
12.	Refueling floor el 757 U1 beside Aux boration makeup tk.	≤ 104
13.	Aux Bldg el 737 U1 outside supply fan room.	≤ 104
14.	Aux Bldg el 713 U1 across from AFW pumps.	≤ 104
15.	Aux Bldg el 692 U1 outside AFW pump room door.	≤ 104
16.	Aux Bldg el 692 U2 near boric acid concentrate filter vault.	≤ 104
17.	Aux Bldg el 676 next to 0-L-629.	≤ 104
18.	Add Equip Bldg U1 el 729 between UHI accumulators.	≥ 70 ≤ 92
19.	Main Control Room south wall.	≤ 90
20.	Main Control Room across from 1-M-9.	≤ 90
21.	D/G Bldg el 742 2B-B D/G room on wall by battery charger.	≤ 120
22.	D/G Bldg el 760.5 next to 480V diesel Aux Bd 2B1-B.	≤ 120
23.	IPS el 741 next to 1A-A ERCW-MCC transformer and board.	≤ 120
24.	IPS el 741 in B train ERCW pump room.	≤ 120
25.	IPS el 741 next to 2A-A ERCW-MCC transformer and board.	≤ 120
26.	Computer room el 708 center of room.	≥ 65 ≤ 75
27.	North steam valve vault room U1 Morgan Temp Recorder.	≥ 80
28.	South steam valve vault room U1 Morgan Temp Recorder.	≥ 80
29.	D/G Bldg el 742 1A-A D/G Room near D/G set	≥ 40
30.	D/G Bldg el 742 1B-B D/G Room near D/G set	≥ 40
31.	D/G Bldg el 742 2A-A D/G Room near D/G set	≥ 40
32.	D/G Bldg el 742 2B-B D/G Room near D/G set	≥ 40
33.	Aux. Instrument Room el 708	≤ 90
34.	Additional D/G Bldg. el 742 D/G Room near D/G set	≥ 40

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3/4.8 ELECTRICAL POWER SYSTEMS

3/4.8.1 A.C. SOURCES

OPERATING

LIMITING CONDITION FOR OPERATION

3.8.1.1 As a minimum, the following A.C. electrical power sources shall be OPERABLE:

a. Two physically independent circuits between the offsite transmission network and the Onsite Class 1E Distribution System, and

b. Four separate and independent diesel generator sets*, each with:

1) Two diesels driving a common generator,

2) Two separate engine-mounted fuel tanks containing a minimum volume of 250 gallons of fuel in each tank,

3) A separate 7 day fuel storage tank containing a minimum volume of 62,000 gallons of fuel,

4) A separate fuel transfer pump, and

5) A separate 125-volt DC distribution panel, 125-volt D.C. battery bank and associated charger.

APPLICABILITY: MODES 1, 2, 3, and 4.

ACTION:

a. With either an offsite circuit or diesel generator set of the above required A.C. electrical power sources inoperable, demonstrate the OPERABILITY of the remaining A.C. sources by performing Specifications 4.8.1.1.1a. ~~and 4.8.1.1.2a.4)~~ within 1 hour and at least once per 8 hours thereafter; and specification 4.8.1.1.2.a.4 within 24 hours; restore at least two offsite circuits and four diesel generator sets to OPERABLE status within 72 hours or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

b. With one offsite circuit and one diesel generator set of the above required A.C. electrical power sources inoperable, demonstrate the OPERABILITY of the remaining A.C. sources by performing Specifications 4.8.1.1.1a. ~~and 4.8.1.1.2a.4)~~ within 1 hour and at least once per 8 hours thereafter; and specification 4.8.1.1.2.a.4 within 8 hours; restore at least one of the inoperable sources to OPERABLE status within 12 hours or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours. Restore at least two offsite circuits and four diesel generator sets to OPERABLE status within 72 hours from the time of initial loss or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

c. With one diesel generator set inoperable, in addition to the requirements of ACTION a. or b. above, verify that:

* The C-S Diesel Generator set may be substituted for any one of the required diesel generator sets provided operability is proven by performance of surveillance requirements 4.8.1.1.2.a.4, 5, and 6.

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LIMITING CONDITION FOR OPERATION

ACTION (Continued)

1. All required systems, subsystems, trains, components and devices that depend on the remaining OPERABLE diesel generator sets as a source of emergency power are also OPERABLE, and

2. When in MODE 1, 2, or 3, the steam-driven auxiliary feedwater pump is OPERABLE.

If these conditions are not satisfied within 2 hours, be in at least HOT STANDBY within the next 6 hours, and in COLD SHUTDOWN within the following 30 hours.

d. With two of the above required offsite A.C. circuits inoperable, demonstrate the OPERABILITY of four diesel generator sets by performing Specification 4.8.1.1.2a.4) within ~~1~~ 8 hours and at least once per 8 hours thereafter, unless the diesel generator sets are already operating; restore at least one of the inoperable offsite sources to OPERABLE status within 24 hours or be in at least HOT STANDBY within the next 6 hours. With only one offsite source restored, restore at least two offsite circuits to OPERABLE status within 72 hours from time of initial loss or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

e. With two or more diesel generator sets inoperable, demonstrate the OPERABILITY of two offsite A.C. circuits by performing Specification 4.8.1.1.1a. within 1 hour and at least once per 8 hours thereafter; restore at least Diesel Generator Sets 1A-A and 2A-A or 1B-B and 2B-B to OPERABLE status within 2 hours or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours. Restore at least four diesel generator sets to OPERABLE status within 72 hours from time of initial loss or be in least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

f. Insert Action f. (attached)

SURVEILLANCE REQUIREMENTS

4.8.1.1.1 Each of the above required independent circuits between the offsite transmission network and the onsite Class 1E Distribution System shall be:

a. Determined OPERABLE at least once per 7 days by verifying correct breaker alignments, indicated power availability, and

b. Demonstrated OPERABLE at least once per 18 months during shutdown by transferring (manually and automatically) power supply from the normal circuit to the first alternate circuit.

4.8.1.1.2 Each diesel generator set shall be demonstrated OPERABLE:#

a. In accordance with the frequency specified in Table 4.8-1 on a STAGGERED TEST BASIS by:*

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*All diesel generator starts for the purpose of this surveillance test may be preceded by an engine prelube period. Further, all surveillance tests, with the exception of once per 184 days, may also be preceded by warmup procedures (e.g., gradual acceleration and/or gradual loading > 60 sec) as recommended by the manufacturer so that the mechanical stress and wear on the diesel engine is minimized.

Surveillance requirements 4.8.1.1.2.a.4, 5, and 6 do not have to be met for the C-S Diesel Generator unless it is being used to satisfy LCO 3.8.1.1 or 3.8.1.2

Proposed Action Statement f

With one or more diesel generator sets inoperable solely because the fuel level in one or more tanks is below the minimum, restore the level to above the minimum within 24 hours; otherwise comply with ACTION Statements a, b, or c above as applicable.

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3) The resistance of each cell to terminal connection is less than or equal to 150×10^{-6} ohm.

d. At least once per 18 months by verifying that the battery capacity is adequate to supply and maintain in OPERABLE status all of the actual or simulated emergency loads for the design duty cycle when the battery is subjected to a battery service test;

e. At least once per 60 months by verifying that the battery capacity is at least 80% of the manufacturer's rating when subjected to a performance test.

f. At least once per 18 months by giving performance discharge tests of battery capacity to any battery that shows signs of degradation or has reached 85% of the service life expected for the application. Degradation is indicated when the battery capacity drops more than 10% of rated capacity from its average on previous performance tests, or is below 90% of the manufacturer's rating.

4.8.1.1.4 ~~Reports — All diesel generator failures, valid or non-valid, shall be reported in a Special Report to the Commission pursuant to Specification 6.9.2 within 30 days. Report of diesel generator failures shall include the information recommended in Regulatory Position C.3.b of Regulatory Guide 1.108, Revision 1, August 1977. If the number of failures in the last 100 valid tests (on a per nuclear unit basis) is greater than or equal to 7, the report shall be supplemented to include the additional information recommended in Regulatory Position C.3.b of Regulatory Guide 1.108, Revision 1, August 1977.~~

Replace with new 4.8.1.1.4 (attached)

4.8.1.1.4 Diesel Generator Reliability Improvement Program

As a minimum the Reliability Improvement Program report for NRC audit shall include:

(a) a summary of all tests (valid and invalid) that occurred within the time period over which the last 20/100 valid tests were performed

(b) analysis of failures and determination of root causes of failures

(c) evaluation of each of the recommendations of NUREG/CR-0660, Enhancement of Onsite Emergency Diesel Generator Reliability in Operating Reactors, with respect to their application to the Plant

(d) identification of all actions taken or to be taken to (1) correct the root causes of failures defined in (b) above and (2) achieve a general improvement of diesel generator reliability

(e) the schedule for implementation of each action from (d) above

(f) an assessment of the existing reliability of electric power to engineered-safety-feature equipment

Once a licensee has prepared and maintained an initial report detailing the diesel generator reliability improvement program at his site, as defined above, the licensee need prepare only a supplemental report within 30 days after each failure during a valid demand for so long as the affected diesel generator unit contiues to violate the criteria (3/20 or 6/100) for the reliability improvement program remedial action. The supplemental report need only update the failure/demand history for the affected diesel generator unit since the last report for that diesel generator. The supplemental report shall also present an analysis of the failure(s) with a root cause determination, if possible, and shall delineate any further procedural, hardware or operational changes to be incorporated into the site diesel generator improvement program and the schedule for implementation of those changes.

In addition to the above, submit a yearly data report on the diesel generator reliability.

Replace with attached

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TABLE 4.8-1

DIESEL GENERATOR TEST SCHEDULE

NUMBER OF FAILURES IN LAST 100 VALID TESTS*	TEST FREQUENCY
≤ 1	At least once per 31 days
2	At least once per 14 days
3	At least once per 7 days
≥ 4	At least once per 3 days

*Criteria for determining number of failures and number of valid tests shall be in accordance with Regulatory Position C.2.e of Regulatory Guide 1.108, Revision 1, August 1977, where the last 100 tests are determined on a per nuclear unit basis. For the purpose of this schedule, only valid tests conducted after the completion of the preoperational test requirements of Regulatory Guide 1.108, Revision 1, August 1977, shall be included in the computation of the "last 100 valid tests."

Table 4.8-1
Diesel Generator Reliability

No. of Failures in last 20 valid tests*	No. of Failures in last 100 valid tests*	Reliability Actions
$\leq$ 1		Test at least once per 31 days
$\geq$ 2		Test at least once per 7 days **
$\geq$ 3	$\geq$ 6	Within 30 days prepare a report for NRC audit, in accordance with Surveillance Requirement 4.8.1.1.4
$\geq$ 5	$\geq$ 11	Perform a requalification test for the affected diesel generator pursuant to the attachment to this table

* Criteria for determining number of failures and number of valid tests shall be in accordance with Regulatory Postion C.2.e of Regulatory Guide 1.108, Revision 1, August 1977, where the number of tests and failures are determined on a per diesel generator unit basisl For the purposes of this test schedule, only valid tests conducted after the Operating License issuance date shall be included in the computation of the "last 20 valid tests". Entry into this test schedule shall be made at the 31 day test frequency.

** This test frequency shall be maintained until seven consecutive failure free demands have been performed and the number of failures in the last 20 valid demands has been reduced to one or less.

Attachment to Table 4.8-1
Diesel Generator Requalification Program

(1) Perform seven consecutive successful demands without a failure within 30 days of diesel generator being restored to OPERABLE status and 14 consecutive successful demands without a failure within 75 days of diesel generator being restored to OPERABLE status.

(2) If a failure occurs during the first seven tests in the requalification test program, perform seven successful demands without an additional failure within 30 days of diesel generator being restored to OPERABLE status and 14 consecutive successful demands without a failure within 75 days of the diesel generator restored to OPERABLE status.

(3) If a failure occurs during the second seven tests (tests 8 through 14) of number 1 above, perform 14 consecutive successful demands without an additional failure within 75 days of the failure which occurred during the requalification testing.

(4) Following the second failure during the requalification test program, be in at least HOT STANDBY within the next 6 hours and COLD SHUTDOWN within the following 30 hours.

(5) During requalification testing the diesel generator should not be tested more frequently than at 24-hour intervals.

After a diesel generator has been successfully requalified, subsequent repeated requalification tests will not be required for that diesel generator under the following conditions:

(a) The number of failures in the last 20 valid demands is less than five.

(b) The number of failures in the last 100 valid demands is less than 11.

(c) In the event that following successful requalification of a diesel generator the number of failures is still in excess of the remedial action criteria (a and/or b above), the following exception will be allowed until the diesel generator is no longer in violation of the remedial action criteria (a and/or b above).

Requalification testing will not be required provided that after each valid demand the number of failures in the last 20 and/or 100 valid demands <u>has not increased.</u> Once the diesel generator is no longer in violation of the remedial action criteria above, the provisions of those criteria alone will prevail.

A.C. SOURCES

SHUTDOWN

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LIMITING CONDITION FOR OPERATION

3.8.1.2 As a minimum, the following A.C. electrical power sources shall be OPERABLE:

a. One circuit between the offsite transmission network and the Onsite Class 1E Distribution System, and

b. Diesel Generator Sets 1A-A and 2A-A or 1B-B and 2B-B* each with:

1) Two diesels driving a common generator,

2) Engine-mounted fuel tanks containing a minimum volume of 250 gallons of fuel per tank,

3) A 7-day fuel storage tank containing a minimum volume of 62,000 gallons of fuel,

4) A fuel transfer pump, and

5) A separate 125-volt DC distribution panel, 125-volt DC battery bank, and associated charger.

APPLICABILITY: MODES 5 and 6.

ACTION:

With less than the above minimum required A.C. electrical power sources OPERABLE, immediately suspend all operations involving CORE ALTERATIONS, positive reactivity changes, movement of irradiated fuel, or crane operation with loads over the fuel storage pool, and within 8 hours, depressurize and vent the Reactor Coolant System through at least a 3 square inch vent. In addition, when in MODE 5 with the Reactor coolant loops not filled, or in MODE 6 with the water level less than 23 feet above the reactor vessel flange, immediately initiate corrective action to restore the required sources to OPERABLE status as soon as possible.

SURVEILLANCE REQUIREMENTS

4.8.1.2 The above required A.C. electrical power sources shall be demonstrated OPERABLE by the performance of each of the requirements of Specifications 4.8.1.1.1, 4.8.1.1.2 (except for Specification 4.8.1.1.2a.5), 4.8.1.1.3, and 4.8.1.1.4.

* The C-S diesel generator set may be substituted for any one of the required diesel generator sets provided operability is proven by performance of surveillance requirements 4.8.1.1.2.a.4, 5, and 6

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TABLE 3.8-2 (Continued)

MOTOR-OPERATED VALVES THERMAL OVERLOAD DEVICES WHICH ARE BYPASSED UNDER ACCIDENT CONDITIONS

VALVE NO.	FUNCTION	BYPASS DEVICE
1-FCV-67-95	Cont. Isol. Lower	Yes
1-FCV-67-96	Cont. Isol. Lower	Yes
1-FCV-67-91	Cont. Isol. Lower	Yes
1-FCV-67-103	Cont. Isol. Lower	Yes
1-FCV-67-104	Cont. Isol. Lower	Yes
1-FCV-67-99	Cont. Isol. Lower	Yes
1-FCV-67-111	Cont. Isol. Lower	Yes
1-FCV-67-112	Cont. Isol. Lower	Yes
1-FCV-67-107	Cont. Isol. Lower	Yes
1-FCV-67-130	Cont. Isol. Upper	Yes
1-FCV-67-131	Cont. Isol. Upper	Yes
1-FCV-67-295	Cont. Isol. Upper	Yes
1-FCV-67-134	Cont. Isol. Upper	Yes
1-FCV-67-296	Cont. Isol. Upper	Yes
1-FCV-67-133	Cont. Isol. Upper	Yes
1-FCV-67-139	Cont. Isol. Upper	Yes
1-FCV-67-297	Cont. Isol. Upper	Yes
1-FCV-67-138	Cont. Isol. Upper	Yes
1-FCV-67-142	Cont. Isol. Upper	Yes
1-FCV-67-298	Cont. Isol. Upper	Yes
1-FCV-67-141	Cont. Isol. Upper	Yes
1-FCV-72-21	Cont. Spray Pump Suction	Yes
1-FCV-72-22	Cont. Spray Pump Suction	Yes
1-FCV-72-2	Cont. Spray Isol.	Yes
1-FCV-72-39	Cont. Spray Isol.	Yes
1-FCV-72-40	RHR Cont. Spray Isol.	Yes
1-FCV-72-41	RHR Cont. Spray Isol.	Yes
1-FCV-72-44	Cont. Sump to Hdr A - Cont. Spray	Yes
1-FCV-72-45	Cont. Sump to Hdr B - Cont. Spray	Yes
1-FCV-26-240	Cont. Isol.	Yes
1-FCV-26-241	Annulus Isol.	Yes
1-FCV-26-242	Annulus Isol.	Yes
1-FCV-26-243	RCP Cont. Spray Isol.	Yes
1-FCV-26-244	Annulus Isol.	Yes
1-FCV-26-245	Annulus Isol.	Yes
1-FCV-68-332	RCS PRZR Rel.	Yes
1-FCV-68-333	RCS PRZR Rel.	Yes
1-FCV-70-153	RHR Ht Ex B-B Outlet	Yes
1-FCV-70-156	RHR Ht Ex A-A Outlet	Yes
1-FCV-70-207	Cont. Demin. Waste Evap. Bldg. Supply	Yes
* 1-FCV-67-72	C-S D/G Ht. Ex.	
* 2-FCV-67-73	C-S D/G Ht. Ex.	

* Testing the bypass of the thermal overload devices for these valves will only be performed when the C-S diesel generator is replacing one of the other four diesel generators.

Enc 2.

Additional Diesel Generator
FSAR Changes

LIST OF REVISED WBN FSAR FIGURES FOR ADGU

2 copies of dwgs sent to T. Kenyon NRR by 12/20/85

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1.2.2.6 Steam and Power Conversion System

The Steam and Power Conversion System consists of a turbine-generator, main condenser, vacuum pumps, Turbine Seal System, Turbine Bypass System, hot well pumps, condensate booster pumps, main feed pumps, main feed pump turbines (MFPT), condenser-feedwater heater, feedwater heaters, heater drain pumps, and Condensate Storage System. The system is designed to convert the heat produced in the reactor to electrical energy through conversion of a portion of the energy contained in the steam supplied from the steam generators, to condense the turbine exhaust steam into water, and to return the water to the steam generator as feedwater.

Each turbine generator unit consists of a tandem arrangement of one double-flow high-pressure turbine and three double-flow low-pressure turbines driving a direct-coupled generator at 1800 RPM. The generator has a nameplate rating of 1,411,000 KVA at 0.9 PF with 75 psig hydrogen pressure. Each unit employs a horizontal, single pressure, triple shell, single pass surface condenser. Return to the steam generator is through three stages of feedwater pumping and seven stages of feedwater heating. Safety relief valves and power operated relief valves, as well as a turbine bypass to the condenser are provided in the steam lines.

1.2.2.7 Plant Electrical System

The Plant Electric Power System consists of the main generators, the unit station service transformers, the common station service transformers, the diesel generators, the batteries, and the electric distribution system. Under normal operating conditions the main generators supply electrical power through isolated-phase buses to the main step-up transformers and the unit station service transformers located adjacent to the Turbine Building. The primaries of the unit station service transformers are connected to the isolated-phase bus at a point between the generator terminals and the low-voltage connection of the main transformers. During operation, station auxiliary power is taken from the main generator through these transformers. During startup and shutdown, auxiliary power is supplied from the 161-kV system through the common station service transformers. The standby onsite power is supplied by four diesel generators.

The Plant Distribution System can receive AC power from either the two nuclear power units, the two independent preferred (offsite) power circuits, or the four 4400 kW diesel-generator ~~standy~~ (onsite) power sources and distribute it to both safety-related and nonsafety-related loads in the plant. The two

STANDBY

AN ADDITIONAL 5TH D.G. IS AVAILABLE WHICH CAN BE SUBSTITUTED FOR ANY ONE OF THE NORMALLY ALIGNED D.G.s.

1.2.3 General Arrangement of Major Structures and Equipment

The major structures are two reactor buildings, a turbine building, and auxiliary building, a control building, a service and office building, ~~a~~ diesel generator buildings, an intake pumping station, and two natural draft cooling towers. The arrangement of these structures is shown in Figure 2.1-5. Plant arrangement plans and cross sections are presented in Figures 1.2-1 through 1.2-14.

pounds per square foot. Design loading considerations, including the snow load, for the reactor shield building and other Category I structures are presented in Sections 3.8.1 and 3.8.4.

No meteorological parameters were used in evaluating the performance of the ultimate heat sink, which consists of a once-through cooling system utilizing the Chickamauga Reservoir on the Tennessee River. A demonstration of adequate water flow past the site is used in the design bases. This is discussed in Section 2.4.11.

The site is located in Region I for Design Basis Tornado considerations. The design conditions assumed for the Watts Bar Nuclear Plant reactor shield building (and other safety-related structures) are the following:

1. 300 mph = rotational speed
2. 60 mph = translational speed
3. 360 mph = maximum wind speed
4. 3 psi = pressure drop
5. 1 psi/sec = rate of pressure drop (3 psi/3 sec is assumed)

These and tornado-driven missile criteria are discussed in Sections 3.5. The fastest mile of wind at 30 feet above ground for a 100-year return period in the site area is slightly greater than 90 mph.[19] The wind load for the Shield Building is based on 95 mph for that level, as discussed in Section 3.3. Estimates of the probable maximum precipitation (PMP) are included in Section 2.4 (Hydrologic Engineering), and the design considerations for the PMP are in Section 3.4 (Water Level (Flood) Design).

3.3 and

2.3.2 Local Meteorology

2.3.2.1 Data Sources

Short-term site-specific meteorological data from the TVA meteorological facility at the Watts Bar Nuclear Plant site are the basis for dispersion meteorology analysis. Long-term data representative of the site or indicative of site conditions for temperature, precipitation, snowfall, humidity, fog, or wind were obtained from climatological records for Chattanooga, Decatur, Knoxville, Oak Ridge, and Watts Bar Dam, all in Tennessee. Short-term records for the Sequoyah Nuclear Plant site were also used. These data source locations are shown relative to the plant site in Figure 2.3-3.

For the Additional Diesel Generator Building The Design Basis Tornado Parameters Are As Follows:

1. 290 mph = Rotational Speed
2. 70 mph = Translational Speed
3. 360 mph = Maximum Wind Speed
4. 3 psi = Pressure Drop
5. 2 psi/sec = Rate of Pressure Drop (3psi/1.5sec is assumed)

Structure		Access	Accesses	Elev.
Intake Pumping Structure	(1)	Access Hatches	2	728.0
	(2)	Stairwell Entrances	2	741.0
	(3)	Access Hatches	6	741.0
Auxiliary and Control Bldgs.	(1)	Door to Turbine Bldg.	1	708.0
	(2)	Door to Service Bldg.	1	713.0
	(3)	Railroad Access Opening	1	729.0
	(4)	Door to Turbine Bldg.	2	729.0
	(5)	Emergency Exit	1	730.0
	(6)	Door to Turbine Bldg.	2	755.0
Shield Building	(1)	Personnel Lock	1	714.0
	(2)	Equipment Hatch	1	753.0
	(3)	Personnel Lock	1	755.0
Diesel Generator Building	(1)	Equipment Access Doors	4	742.0
	(2)	Emergency Exits	4	742.0
	(3)	Personnel Access Door	1	742.0
	(4)	Emergency Exit	1	760.5

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Exterior accesses are also provided to each of the class IE electrical systems manholes and handholes at elevations varying from 714.5 feet MSL to 728.5 feet MSL, depending upon the location of each structure.

The relationship of the plantsite to the surrounding area can be seen in Figures 2.1-4 and 2.1-5. It can be seen from these figures that significant natural drainage features of the site have not been altered. Local surface runoff drains into the Tennessee River.

2.4.1.2 Hydrosphere

The Watts Bar Nuclear Plant site, along with the Watts Bar Dam Reservation, comprises approximately 1770 acres on the west bank of Chickamauga Lake at Tennessee River mile(TRM) 528. As shown by Figure 2.1-4, the site is on high ground with the Tennessee River being the major potential source of flooding.

The Tennessee River above the Watts Bar plantsite drains 17,319 square miles. Watts Bar Dam, 1.9 miles upstream, has a drainage area of 17,310 square miles. Chickamauga Dam, the next dam downstream, has a drainage area of 20,790 square miles. Two major tributaries--Little Tennessee and French Broad Rivers--rise to the east in the rugged Southern Appalachian Highlands. They flow northwestward through the Appalachian Divide which is essentially defined by the North Carolina-Tennessee border to join the Tennessee River which flows southwestward. The Tennessee River and its Clinch and Holston River tributaries flow southwest | 50

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STRUCTURE	ACCESS	NUMBER OF ACCESSES	ELEVATION
ADDITIONAL DIESEL GENERATOR BUILDING	(1) EQUIPMENT ACCESS DOOR	2	742.0
	(2) PERSONNEL ACCESS DOOR	1	742.0
	(3) EMERGENCY EXIT	1	742.0
	(4) EMERGENCY EXIT	1	760.5

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would be in the month of March or possibly the first week in April.

Figure 2.4-98 shows the main plant general grading plan. The diesel generator buildings to the north and the pumping station to the east of the main building complex must be protected from flooding to assure plant safety. The diesel generator buildings ~~has it~~ operating floors are at elevation 742 which ~~is~~ are well above the maximum computed elevation including wind wave runup. The pumping station is shielded from direct wave action on all sides except to the south by either buildings, earth embankments, or 39 41
the cooling towers. The maximum effective fetch of 1.3 miles occurs from both the southwest and northeast directions (Figure 2.4-67). This allows for the sheltering effect of several hills on the south riverbank which become islands at maximum flood levels.

For the Watts Bar FSAR, the two-year extreme wind for the season in which the PMF could occur was adopted to associate with the PMF crest as specified in Regulatory Guide 1.59. The storm studies on which the PMF determination is based [4] show that the season of maximum rain depth is the month of March. Wind velocity was determined from a statistical analysis of maximum March winds observed at Chattanooga, Tennessee.

Records of daily maximum average hourly winds for each direction are available at the Watts Bar site for the period May 23, 1973, through April 30, 1978. This record, however, is too short to use in a statistical analysis to determine the 2-year extreme wind, as specified in ANSI Standard N170-1976, an appendix to 39
Regulatory Guide 1.59. Further, the necessary 30-minute wind data are not available. To determine applicability of Chattanooga winds at the Watts Bar plant, a Kolmogorov-Smirnov (K-S) statistical test was applied to cumulative frequency distributions of daily maximum hourly winds for each direction at Chattanooga and Watts Bar. The winds compared were those recorded at Chattanooga during the period 1948-74 (the period when the necessary triple-register records were available for analysis) and the Watts Bar record. A concurrent record is not available; however, the K-S test showed that (except for the noncritical east direction) the record of daily maximum hourly velocities at Chattanooga were equal to or greater than that at Watts Bar. From this analysis it was concluded that use of the Chattanooga wind records to define seasonal maximum winds at the Watts Bar site is conservative.

2.4.14.1.3 Post Flood Period

Because of the improbability of a flood above plant grade, no detailed procedures will be established for return of the plant to normal operation unless and until a flood actually occurs. If flood mode operation (Section 2.4.10.2) should ever become necessary, it will be possible to maintain this mode of operation for a sufficient period of time (100 days) so that appropriate recovery steps can be formulated and taken. The actual flood waters are expected to recede below plant grade within 1 to 4 days.

2.4.14.1.4 Localized Floods

Localized plant site flooding due to the probable maximum storm (Section 2.4.3) will not enter vital structures or endanger the plant. Plant shutdown will be forced by water ponding on the 28 switchyard and around buildings and water entry into the Turbine Building, but this shutdown will be similar to a loss of offsite power situation as described in Chapter 15. The other steps described in this subsection are not applicable to this case. Refer to Section 2.4.2.3.

2.4.14.2 Plant Operation During Floods Above Grade

"Flood mode" operation is defined as the set of conditions described below by means of which the plant will be safely maintained during the time when flood waters exceed plant grade (elevation 728) and during the subsequent period until recovery (Section 2.4.14.7) is accomplished.

2.4.14.2.1 Flooding of Structures

Only the Reactor Building will be maintained dry during the flood mode. Walls and penetrations are designed to withstand all static and dynamic forces imposed by the DBF; minor seepage through the concrete walls will be collected in the Reactor 28 Building sump and pumped out of the Building.

The Diesel Generator Buildings will remain dry during the flood mode since its lowest floor is at elevation 742. All other structures, including the Service, Turbine, Auxiliary, and Control Buildings, will be allowed to flood as the water exceeds their grade level entrances. Equipment that is located in these structures and required for operation in the flood mode is either above the DBF or designed for submerged operation.

3.3.1 Wind Loadings

3.3.1.1 Design Wind Velocity

The Category I structures are designed for a 95-mile per hour wind, 30 feet above grade, with a 100 year recurrence interval. The wind was determined from Figure 1, ASCE paper 3269, "Wind Forces on Structures" [3]. The wind was applied for the full height of the structure. A gust factor of 1.1 is included for all wind loads and combinations of loads where wind is involved as recommended in ASCE paper 3269 [3].

3.3.1.2 Determination of Applied Force

The pressure and pressure distribution of wind loads on structures were determined by the methods described in ASCE Paper 3269[3]. The dynamic wind pressure, q, is defined as $q = .00256V^2$, where q is in psf and V is in mph. A gust factor of 1.1 is applied which redefines q as $q = .00256\ (1.1V)^2 = .00310V^2$. The wind pressure, p, in psf, is defined as $p = Cq$ where C is the pressure distribution coefficient (C_{pe} or C_{pi}) or the shape coefficient (C_D) determined from Table 4 in ASCE Paper 3269.[3] 38 38

For the analysis of box-shaped structures, a shape coefficient (C_D) of 1.3 is used which defines the wind pressure as $p = 1.3q$. Of the total pressure ($p = 1.3q$), 0.8q is applied to the windward wall, and 0.5q is applied to the leeward wall. Concurrently the end walls receive 0.7q negative pressure and the roof receives 0.5q uplift. 38

For the analysis of cylindrical structures, such as the shield buildings and storage tanks, the shape coefficients and pressure distribution coefficients are obtained from Table 4(f) of ASCE Paper 3269[3].

3.3.2 Tornado Loadings

3.3.2.1 Applicable Design Parameters

All Category I structures except for the additional diesel generator buildin are designed for a "funnel" of wind moving with a translational velocity of 60 miles per hour and having a rotational velocity of 300 miles per hour. ~~All~~ Category I structures are also designed for an external depressurization of 3 psi occurring in 3 seconds.

The tornado loading for the additional diesel generator building is discussed in section 2.3.1.

Information about the spectrum and pertinent characteristics of tornado-generated missiles is in Section 3.5.

fire protection system inside the Control Building is not pressurized until it is actuated.

3.5.1.1.5 ERCW Structures

At the Intake Pumping Station the essential raw cooling water (ERCW) pump motors are exposed to the atmosphere. A structural steel grillage system, discussed in Section 3.8.4, provides protection to the pumps from tornado missiles. A concrete shield wall separates the four motors of Train A from those of Train B. These components are arranged in a straight line over a distance of about 100 feet. An overspeed failure is not postulated for these pumps. Even if a failure were postulated, no credible trajectory of any resultant missile could damage enough components to reduce the number available to less than four. No credible failure of any high-pressure component could create a missile which could reduce the availability of pumps on the opposite power train. 42

No credible, potential internal missile sources are installed in the remainder of the ERCW structure. 42

3.5.1.1.6 ERCW Pipe Tunnels and RWST Foundations

No credible potential internal missile sources are installed in these structures.

3.5.1.1.7 Diesel Generator Building

Four emergency diesel generators, which are required to supply emergency power to certain engineered safety features, are located inside a separate structure, the Diesel Generator Building. Interior walls of reinforced concrete separate these generators.

There is a mechanical governor on the diesel engine of each diesel-generator unit which is designed to assume control of the engine when there is a tendency to overspeed. In addition, the diesel generators have an overspeed trip which cuts off fuel to the diesel engine upon an overspeed condition. Consequently, no missiles are postulated for overspeed conditions of the generator. The diesel generator units are protected from the effects of a postulated failure of the carbon dioxide storage tank by an 18-inch thick reinforced concrete wall. Therefore, any missiles or pressure build-up generated by a rupture of the carbon dioxide storage tank would not damage essential equipment. The vent path for the carbon dioxide storage tank compartment is through one set of standard double doors into a stairwell. If additional pressure relief is required, the vent path will be through another set of standard double doors which open to the atmosphere from the stairwell. 49 51

ADDITIONALLY, A 5TH C-S D.G. WHICH MAY BE SUBSTITUTED FOR ANY ONE OF THE NORMALLY ALIGNED D.G.S IS LOCATED WITHIN THE SEPARATE ADDITIONAL DIESEL GENERATOR BUILDING.

ince each step in the development of the analytical model escribed in Section 3.5.1.3.5 contains one or more conservative assumptions, all aspects associated with these two analyses support the contention that the turbine missile hazard at this plant is not significant.

In addition, the plant uses turbines designed, manufactured, installed, and operated in accordance with standards that minimize the possibility of an accident that may produce dangerous missiles. Each reactor unit has its essential, safety-related equipment installations and structures positioned to minimize the strike probability on these items.

Such findings indicate that the turbine missile hazard at the Watts Bar Nuclear Plant is sufficiently small to be considered an acceptable risk.

3.5.1.4 Missiles Generated By Natural Phenomena

Category I structures at Watts Bar Nuclear Plant are designed for tornado-generated missiles based on the following criteria:

1. Spectrum A (see Table 3.5-7) was used in the design of the structures using the following basis.

    a. Structures that are duplicates of structures designed and constructed at Sequoyah Nuclear Plant (SNP).

    b. Structures that, although dissimilar to any structures used at SNP, have been constructed or designed such that a redesign would require a delay in the construction schedule.

2. Spectrum B (see Table 3.5-8) was used in the design of the equipment doors on the Diesel Generator Building.

3. Spectrum C (see Table 3.5-9) was used in the design of the structures using the following basis:

    a. Structures not covered by items 1(a), 1(b), ~~and~~ 2 ~~above~~, and 4.

    b. Special structural protection, such as the structural protection from vertical missiles for the ERCW pumps on the intake pumping station.

4. Spectrum D (See Table 3.5-17) was used in the design of the Additional Diesel Generator Building and any additional Category I structures after July 1979.

Values obtained from this technique have been corroborated with subsequent reports by the National Highway Safety Bureau. In reference [5], time histories of forces are presented for several automobile crash tests which are closely confirmatory. The impact loads obtained by the previously described methods were then applied to the structures and the structures were anlayzed for the effect of the loads by conventional analytical methods. Impact loads from the missiles of Spectrum C (Table 3.5-9) were calculated using the procedures of reference 8. See Section 3.5.1.4 for a discussion of structures designed for Spectrum C. 51

Tornado missile protection for all safety-related buried piping is provided by one of the four protective schemes described below.

1. 10 feet of compacted fine-grained soil.

2. 7 feet of compacted crushed stone.

3. 18 inches of conventional unreinforced concrete.

4. 18 inches of roller-compacted unreinforced concrete.

In each scheme a 12-inch cushion of either compacted sand or fine-grained earthfill is required over the top of the pipe.

The acceptability of each scheme has been verified by a full-scale test program in which missiles from the NRC spectrum were dropped from a helicopter into test pits of crushed stone or earthfill and onto concrete slabs. The missiles used in the testing were:

1. a 1500-pound utility pole,

2. a 12-inch diameter schedule 40 steel pipe, 45

3. a 1-inch diameter steel rod,

4. a 3-inch diameter schedule 40 steel pipe, and

5. a 6-inch diameter schedule 40 steel pipe.

Of these missiles the 12-inch pipe and utility pole caused the greatest penetration depths. Impact velocities of 200-215 ft/s were achieved for both the utility pole and 12-inch pipe which equals or exceeds the design velocities for those missiles as listed in tables 3.5-7 and 3.5-9. The protective thicknesses listed above are based on the maximum thicknesses observed in the test program and are, therefore, conservatively chosen.

It is concluded that the missile protection criteria to which the plant has been analyzed and protected against comply with the intent of Criterion 4 of 10 CFR 50, Appendix A, General Design Criteria for Nuclear Power Plants.

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3.5.3.1 Additional Diesel Generator Building (And Other Category I Structures Added After July 1979)

The openings in the walls and roof for access, ventilation, air intakes, and exhaust discharge, are designed to withstand the effects from the tornado missiles listed in Spectrum D of Table 3.5-17. Overall structural response of concrete barriers to tornado missile impact was performed using the general requirements of Appendix C, ACI 349-76, "Code Requirements For Nuclear Safety-Related Concrete Structures." Methodology for implementation of the requirements is given in topical report TVA-TR78-4, "Design of Structures For Missile Impact" and in TVA Civil Design Guide DG-C1.5.7, "Design of Slabs For Missile Impact." Minimum concrete thickness required to resist penetration, perforatic or backface scabbing from these tornado missiles are given in Table 3.5-18.

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3.7 SEISMIC DESIGN

3.7.1 Seismic Input

3.7.1.1 Design Response Spectra

The site seismic design response spectra which define the vibratory ground motion of the Operating Basis Earthquake and the Safe Shutdown Earthquake for rock-supported structures are shown in Figures 2.5-236a and 2.5-236b, Section 2.5. The maximum rock acceleration for the SSE is 0.18g for horizontal motion and 0.12g for vertical motion. The Operating Basis Earthquake is equal to one-half the SSE, as outlined in Section 2.5.2.7, with a maximum horizontal rock acceleration of 0.09g and 0.06g vertically.

In response to an NRC question relating to the adequacy of the seismic design basis, TVA performed a site specific study. Site specific design response spectra were developed; see Section 2.5.2.4. The site specific response spectra are termed the 84th percentile design basis response spectra. 51

In response to the NRC's review of the liquefaction potential of the soils along the ERCW pipeline and 1E conduit alignment, TVA performed a site-specific study of the top-of-ground motion; see Section 2.5.2.4 for a discussion of this study.

3.7.1.2 Design Time History

Four artificial time histories have been developed so that the response spectra produced by the arithmetic average of the response spectra of each individual record will envelope the site seismic design response spectra for corresponding damping ratios. Figures 3.7-1 thru 3.7-4 show a comparison, for various damping ratios, of these averaged response spectra and the site seismic design response spectra for the OBE. Table 3.7-1 lists the system period intervals at which the response spectra are calculated.

3.7.1.3 Critical Damping Values

The specific percentage of critical damping values used for Category I structures, systems, and components are provided in Tables 3.7-2 and 3.7-24.

3.7.1.4 Supporting Media for Seismic Category I Structures

A complete description of the supporting media for each seismic Category I structure is provided in Section 2.5. Pertinent data concerning the supporting media for each of the seismic Category I structures is also given in Table 3.7-3.

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SEISMIC DESIGN

Throughout this section the terms Criteria "A" and Criteria "B" will be used and defined as follows : Criteria "A" defines the analytical techniques used in the dynamic earthquake analysis of the original Category I structures and are applicable to new Category I structures. Criteria "B" defines the analytical techniques that are based on more recent analytical procedures in seismic analysis and seismic load combiinations.

3.7.1 Seismic Input

3.7.1.1 Design Response Spectra

Vibratory ground motions are defined by two sets of site seismic design response spectra. Those that have been in use throughout the plant design are termed Criteria "A" and those that can optionally be used in analyses after July 23,1979 are termed Criteria "B" .

3.7.1.1.1 Criteria "A"

The Criteria "A" site seismic design response spectra which define the vibratory ground motion of the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE) for rock-supported structures are shown in Figures 2.5-236a and 2.5-236b, Section 2.5 . The maximum rock acceleration for the SSE is 0.18g for horizontal motion and 0.12g for vertical motion. The OBE is equal to one-half the SSE, as outlined in Section 2.5.2.7, with a maximum horizontal rock acceleration of 0.09g and 0.6g vertically. These spectra were used in the analysis of structures before July 23, 1979.

In 1978-79 in response to an NRC question relating to the adequacy of the seismic design basis, TVA performed a site specific study to justify the Criteria "A" design basis. Site specific design response spectra were developed; see Section 2.5.2.4 . These spectra are termed the 84th percentile design basis response spectra.

In a 1983 response to the NRC's review of the liquefaction potential of the soils along the ERCW pipeline and 1E conduit alignment, TVA performed additional site-specific studies of the top-of-ground motions to further justify the Criteria "A" design basis. See Section 2.5.2.4 for a discussion of this study.

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3.7.1.1.2 CRITERIA "B"

Criteria "B" site seismic design response spectra were developed to conform to the requirements of Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Plants" (reference 10). These spectra have been optionally utilized for design analyses after July 23, 1979. The Criteria "B" maximum horizontal and vertical accelerations at top-of-rock for the SSE are 0.18g and for the OBE 0.09g. The Criteria "B" site seismic design response spectra which define the vibratory horizontal and vertical top-of-rock motion for the SSE are shown on Figures 3.7-4a through 3.7-4r . The OBE spectra are determined by scaling the SSE spectra by a factor of one-half.

3.7.1.2 Design Time History

3.7.1.2.1 Criteria "A"

For time history analyses four artificial time histories were developed so that the response spectra produced by the arithmetic average of the response spectra of each individual record will envelope the site seismic design response spectra for corresponding damping ratios. Figures 3.7-1 thru 3.7-4 show a comparison, for various damping ratios, of these averaged response spectra and the site seismic design response spectra for the OBE. Table 3.7-1 lists the system period intervals at which the response spectra are calculated.

3.7.1.2.2 CRITERIA "B"

An additional series of design time histories were developed for optional use in analyses after July 23,1979. These consist of three statistically independent artificial accelerograms consisting of two horizontal and one vertical component. The three components of the earthquake are assumed to occur simultaneously. Response spectra produced from these records envelop the appropriate seismic design response spectra discussed in Section 3.7.1.1.2 . For soil-supported structures, design accelerograms may be determined as discussed in Section 3.7.2.4.1 using real earthquakes defined for the site.

3.7.1.3 Critical Damping Values

The specific percentage of critical damping values used for Category I structures, systems, and components are provided in Tables 3.7-2a, 3.7-2b, and 3.7-24.

3.7.1.4 Supporting Media for Seismic Category I Structures

A complete description of the supporting media for each seismic Category I structure is provided in Section 2.5 . Pertinent data concerning the supporting media for each of the seismic Category I structures is also given in Table 3.7-3 .

The lumped mass model of the building for the normal mode analysis consists of four mass points and four elements, the mass and inertia of the base, and translational and rotational springs representing the pile group. The mass points, elements, and spring properties are given in Table 3.7-23A.

The pile group is composed of 104 vertical and 46 batter piles. The pile group was modeled by equivalent translation and rocking springs in both horizontal directions and a vertical spring.

Once a set of spring constants were determined, the lateral and rocking springs were both modified by the same factor to produce a natural period for the structure of 0.15 second in each horizontal direction to correspond to the peak in the top of ground acceleration response spectrum. The spring constants representing the pile group are shown in Table 3.7-23A.

A normal mode time history analysis of the lumped mass model was conducted. A damping factor of 5 percent of critical was used in this step of the analysis for both soil springs and structural elements. The loads thus compared were considered to be overly conservative, and since the top of ground horizontal accelerations were approximately doubled by the base springs, the horizontal loads in the building were reduced by one-half. A plan strain analysis of the soil-structure system was then conducted for the SSE in the E-W and vertical directions to verify the reduction in the horizontal loads computed by the normal mode analysis. The input accelerations for the latter analysis were the top of rock acceleration records specified for the Watts Bar Nuclear Plant. 43

The plane strain analysis was conducted using a 2-dimensional model of the soil-structure system in order to verify reducing the results obtained in the normal mode analysis. The model included soil-structure interation effects, and cases were run with and without the pile group stiffness included in the soil properties. Damping factors of 10 percent of critical for the soil elements and 5 percent of critical for the base mat and CDWE Building elements were used in the plan strain analysis. The soil properties are linear and elastic.

The time history accelerations specified for top of rock were applied at the base of the model, and the free field top of ground acceleration was compared to the lumped mass model top of ground motion. The plane strain analysis indicated the horizontal acceleration amplification through the soil and base springs in the lumped mass analysis was excessive and a reduction of the horizontal loads in the building by a factor of one-half was justified.

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Additonal Diesel Generator Building

The idealized lumped mass model of the reinforced concrete struture used in the analysis is shown in Figure 3.7-15B . Element properties are given in Table 3.7-23B and mass point properties in Table 3.7-23C . Due to the structure's high torsional frequency and small eccentricity, coupling between translation and torsion was not significant and consequently, was not considered.

The Additional Diesel Generator Building (ADGB) is supported on a grid of 154 steel piles driven through in-situ soil and into a firm layer of basel gravel. The dynamic analysis was performed in accordance with recent criteria which specify a three-dimensional simultaneously applied earthquake loading (Criteria B).

The dynamic analysis of the ADGB used real earthquakes defined for the site wit a maximum acceleration of 0.18g at top of rock, see Section 2.5.2.4 . This earthquake was amplified up through the soil to a maximum acceleration of 0.35g in the free field (i.e. ,away from the structure). The amplified earthquake was eneveloped by a Regulatory Guide 1.6 response spectrum with a maximum acceler-t[illegible] of 0.35g . The earthquake defined at the base slab of the structure [illegible] a corresponding maximum acceleration of 0.42g for the SSE and 0.29g for the OBE.

The dynamic analysis was performed in two parts. The structural responses were obtained by the normal modes response spectrum analysis and the response spectr were generated by the normal modes time-history solution. Structural damping of 4-percent and 7-percent was used for the OBE and SSE, respectively. The structural responses and response spectrum were computed for the OBE and SSE. Listed in Table 3.7-23D are the natural frequencies of the structure that were considered in the dynamic analysis.

Response spectra were produced for the damping values of 0.005, 0.01, 0.02, 0.03, 0.04, 0.05, and 0.07 for motion in the east-west, north-south, and vertic direction. Response spectra were also computed at frequency variable damping of 5% to 10 hertz, decreasing linearly to 2% at 20 hertz, and remaining at 2% to 33 hertz as described in ASME Code Class N-411.

The natural frequencies of Westinghouse supplied components are considered in the system seismic analysis. The natural frequencies are listed in detail in the component stress reports.

3.7.2.3 Techniques Used for Modeling

3.7.2.3.1 Other Than NSSS

The procedures used to formulate a mathematical model of each category I structure have been discussed in Sections 3.7.2.1.1 and 3.7.2.1.2. The mass of supported equipment was considered in the lumped masses at the points of support. The stiffness of supported equipment was not considered in the lumped mass model of the structure.

3.7.2.3.2 For NSSS Analysis

The first step in any dynamic analysis for a system or component supplied by Westinghouse is to model the structure or component, i.e., convert the real structure or component into a system of masses, springs, and dash pots suitable for mathematical analysis. Essentially, the procedure is to select mass points so that the displacements obtained will be a good representation of the motion of the system or component. Stated differently, the true inertia forces are not altered so as to appreciably affect the internal stresses in the structure or component.

The mathematical model used for the dynamic analysis of the reactor coolant system is shown in Figure 5.2-1. Figure 5.2-2 shows the mathematical model of the reactor pressure vessel.

The determination as to whether the structure or component is analyzed as part of a system analysis or independently as a subsystem is justified on a case by case basis.

3.7.2.4 Soil Structure Interaction

3.7.2.4.1 Criteria "A"

For Category I structures founded upon soils the rock motion was amplified to obtain the ground surface motion by considering the soil deposit as an elastic medium and making a dynamic analysis of a slice of unit thickness using only the horizontal shearing resistance of the soil. The four artificial earthquakes mentioned in Section 3.7.1.2 were considered as the input motion at top of rock. Once the time history of surface accelerations was known, a response spectrum was produced for the analysis of the soil-supported structure. The vertical surface motion was considered as two-thirds of the horizontal surface motion.

The soil amplification analysis is affected by the accuracy of in site soil measurements, slanted soil layers, soil density variations, and depth of the soil deposit. Therefore, for structures supported on a soil deposit with variations in properties and overburden depths, the parameters of the soil deposit beneath the structure were varied to obtain a series of ground motion spectra. An envelope was drawn from these spectra resulting in the final ground motion spectrum used in analyzing the structure.

By following the procedure outlined, the maximum amplification of the ground response was obtained and the peak width of the ground response spectrum was wide enough to allow for variations in the frequencies of the structure due to variations in soil parameters.

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3.7.2.5 Development of Floor Response Spectra

3.7.2.5.1 Criteria "A"

Response spectra for use in computing the response of structural appurtenances, or of equipment attached to Category I structures were produced by the time-history modal analysis technique. The four artificially produced accelerograms (Section 3.7.1.2) were the input motion at top of rock. To obtain a set of response spectra for one mass point for one direction of motion, the procedure outlined in Figure 3.7-37 was used.

Spectral values were computed for ~~60~~ 55 periods using the distributions shown in Table 3.7-1, Section 3.7.1.2. In all time-history calculations a time interval of 0.010 second was used.

Response spectra were computed for percentages of critical equipment damping of 0.5, 1.0, 2.0, 3.0, 4.0, 5.0 and ~~3~~7.0. Response spectra are also computed at frequency variable damping of 5% to 10 hertz, decreasing linearly to 2% at 20 hertz, and remaining at 2% to 33 hertz as described in ASME Code Case N-411. Response spectra were calculated for both the OBE and SSE; except, for those instances when the same percentage of critical structural damping was specified for both earthquakes, response was calculated for the OBE or SSE only (the SSE results equal twice the OBE). 55

Horizontal response spectra were produced at ground level and at all major floors and at other points of interest within the structure for both east-west and north-south directions, except where symmetry justifies the use of one direction.

For a direction in which torsion is considered, the time histories of accelerations used to produce the spectra will be computed where the maximum accelerations occur at that level (the farthest points on the structure from the shear center, on the axis perpendicular to motion).

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3.7.2.4.2 CRITERIA "B"

For Category I structures founded upon soil, the acceleration at top-of-rock will be considered to be amplified (or attenuated) through the soil. The value of amplification and the change in frequency content of the excitation will be found by a finite element dynamic analysis method that incorporates nonlinear soil properties. The soil amplification analysis is influenced by the accuracy of the determination of the in-situ soil properties, ground water elevation, soil stratification, soil density variations, and variation in bedrock elevation. Therfore, the soil properties beneath the structure will be varied using engineering judgment to obtain different ground motion histories. From these, response spectra will be produced, and an envelope will be drawn encompassing these spectra, resulting in the final ground motion spectrum which will be used in analyzing the structural response.

Unless otherwise noted, vertical response spectra were produced at ground and at the point of maximum structural amplification. The response spectra for ground was used throughout that portion of the structure where no structural amplification occurred. For other points, values were interpolated linearly between the response spectra for ground and for the point of maximum structural amplification.

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3.[illegible]2.5.2 CRITERIA "B"

Repsonse spectra for use in computing the response of structural appurtenances or of equipment attached to Category I structures, are produced by the time history modal analysis technique. The artificially produced accelerograms (Section 3.7.1.2.2) are the input motion at top-of-rock. From the time history analysis the accelerations at some point in the x, y, and z directions due to the three components of the earthquake acting simultaneously are as follows:

$$u_x(t) = u_{x1}(t) + u_{x2}(t) + u_{x3}(t)$$

$$u_y(t) = u_{y1}(t) + u_{y2}(t) + u_{y3}(t)$$

$$u_z(t) = u_{z1}(t) + u_{z2}(t) + u_{z3}(t)$$

Using these time histories, floor response spectra are developed for each direction.

Spectral values are computed for 55 periods using the distributed shown in Table 3.7-1, Section 3.7.1.2 . Spectral values are also calculated at the significant periods of the structure and at periods within +0.0006 seconds of the structure's periods at intervals of 0.0002 seconds. In all time history calculations, a time interval of 0.010 second is used.

Response spectra are computed for critical equipment damping of 1.0, 2.0, 3.0, 4.0, 5.0, and 7.0 percent except where special considerations are required. Response spectra are calculated for both the SSE and the OBE.

For horizontal directions in which torsion is considered, the time history of accelerations used to produced the spectra for some level in a structure are computed where the maximum accelerations occur at that level (at the farthest points on the structure from the shear center, on the axis perpendicular to motion).

3.7.2.6 ~~Three~~ Components of Earthquake Motion

3.7.2.6.1 Criteria "A"

The seismic response of Category I structures was computed by assuming earthquakes motion in each of the two major horizontal directions to occur separately but simultaneously with earthquake motion in the vertical direction. The derivation of the site response spectra and the design time histories for horizontal and vertical motion has been detailed in Sections 3.7.1.1 and 3.7.1.2 respectively.

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3.7.2.7 Combination of Modal Responses

3.7.2.7.1 Other Than NSSS

3.7.2.7.1.1 Criteria "A"

The response of all Category I structures was computed by the response spectrum modal analysis method. The response was calculated in each component mode. The total response was then calculated by determing the square root of the sum of the squares (SRSS) of the modal responses. For example, the total acceleration in any direction was calculated as

$$a_T = \sqrt{a_1^2 + a_2^2 + \ldots + a_n^2}$$

Similar expressions exist for the other responses.

When the frequencies of two or more modes are found to be closely spaced (modes whose frequencies are within 10 percent of each other), the responses of these modes were combined in an absolute manner. The resulting total was treated as that of a pseudomode and combined with the remaining modes by the SRSS method.

The stresses in the structures were calculated assuming either horizontal earthquake to occur simultaneously with the vertical earthquake. For example, a typical expression for the stress x, caused by a horizontal earthquake in the x-direction and a vertical earthquake in the z-direction, would be

$$\sigma_x = \pm \sigma_{xx} + \sigma_{xy}$$ 5

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3.7.2.7.2 NSSS System

The total seismic response of systems and components within Westinghouse scope of responsibility is obtained by combining the individual modal responses utilizing the square root of the sum of the squares method. For systems having modes with closely spaced frequencies, this method is modified to include the

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3.7.2.6.2 CRITERIA "B"

The seismic responses of the Category I structures are determined from three-dimensional lumped mass models assuming the three components of the earthquake are occurring simultaneously.

When the response spectra method is used for seismic analysis, the maximum structural response due to each of the three components of earthquake motion is combined by maximum codirectional responses caused by each of the three components of earthquake motion at a particular point of the structure.

When the time history analysis method is used, the responses from each of the three components of earthquake motion are combined at each time step algebraically. The three components of the earthquake are statistically independent.

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.2.7.1.2 Criteria "B"

The response spectra method was used to determine the seismic responses for the Category I structures, the most probable response was obtained as the square root of the sum of the squares from the individual modes.

When the frequencies of two or more modes are found to be closely spaced (mode whose frequencies are within 10 percent of each other), the responses of these modes were combined in a absolute manner. The resulting total was treated as that of a pseudomode and combined with the remaining modes by the square root of the sum of the squares.

spectral values within a ± 10 percent band of the computed period of the system, equipment, or components will be used for analysis purposes. As an option, response spectra peak shifting as defined in ASME Code Case N-397 was used in some cases. 55

For the soil-supported structures in which floor response spectra were produced, the soil properties were varied to account for inaccuracies in determining soil properties. The effect of these variations were accounted for in the generation of floor response spectra. Soil-structure interaction was considered as discussed in Sections 3.7.2.1 and 3.7.2.4.

3.7.2.10 Use of Constant Vertical Load Factors

3.7.2.10.1 Other Than NSSS

3.7.2.10.1.1 Criteria "A"

A vertical lumped mass dynamic analysis using the techniques outlined in Sections 3.7.2.1.1 and 3.7.2.1.2 was performed for all the Category I structures to determine the vertical loads. The results for each horizontal earthquake analysis were separately added on an absolute basis to those from the vertical earthquake analysis. Constant vertical load factors were not used unless the dynamic analysis indicated the structure behaved as a rigid body in the vertical direction.

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3.7.2.10.2 For NSSS

Constant vertical load factors are not used as the vertical floor response load for the seismic design of safety related systems and components within Westinghouse scope of responsibility.

3.7.2.11 Methods Used to Account for Torsional Effects

The dynamic analysis of structures is discussed in Section 3.7.2.1. The structures were analyzed for torsional effects using a lumped-mass cantilever beam model which adequately represents all stiffness and inertial characteristics. This includes the torsional moment of inertia, eccentricity, and mass moment of inertia.

In the process of preparing lumped-mass mathematical models for the structures, the location of both the center of rotation and center of mass for each floor were computed. Accelerations and deflections were calculated where their maximum values occurred (at the farthest points on the structure from the shear center, on the axis perpendicular to the direction of motion).

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3.7.2.10.1.2 Criteria "B"

The Category I structures, systems, and components, when analyzed for vertical motion, used lumped-mass dynamic techniques as discussed in Section 3.7.2.1.1 The results from both orthogonal horizontal earthquake analyses and the vertic earthquake were combined using the square root of the sum of the squares of th three-component earthquake responses. For systems and components the appropria floor response spectra was used in the analysis. The dynamic mathematical of the supports of the systems and components.

The models described above were subjected to seismic excitations and the resultant responses in the form of frequencies, mode shapes, loads, and stresses were obtained.

3.7.2.12 Comparison of Responses

Figure 3.7-38 shows a comparison of the accelerations obtained from the modal analysis time-history and the response spectrum methods for the interior concrete structure. The comparison demonstrates the conservatism obtained by using a set of 4 artificial time histories whose response spectra envelope the site design response spectra.

The systems and components in Westinghouse scope of analysis were analyzed by response spectra methods.

3.7.2.13 Methods for Seismic Analysis of Dams

Since no dams are utilized to impound bodies of water to serve as heat sinks, this section is not applicable to this site.

3.7.2.14 Determination of Category I Structure Overturning Moments

3.7.2.14.1 Criteria "A"

From the dynamic analyses of the structures, the seismic moments, shears, and vertical loads were determined at the base of the structure. These loads were used in combination with other appropriate loads in determining total overturning effects as discussed in Section 3.8.

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3.7.2.15 Analysis Procedure for Damping

None of the models used for Category I structures were coupled together, therefore the damping values used were as shown in Table 3.7-2 of Section 3.7.1.3.

For systems and components with different elements coupled together in the same dynamic model, the lower percent damping was used in the analysis.

Under the Westinghouse standard scope of supply and analysis, the lowest damping value associated with each element of the system is used for all modes.

3.7.3 Seismic Subsystem Analysis

3.7.3.1 Seismic Analysis Methods for Other Than NSSS

The seismic analysis of Category I piping systems is described in detail in Section 3.7.3.8. The seismic analysis of Category

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3.7.2.14.2 Criteria "B"

From the response spectra modal analysis, the modal moments, shears, and vertic loads were computed in each component mode. The total repsonse was found by taking the square root of the sum of the squares of the modal responses.

The earthquake moment, shear, and vertical load were used in combination with other appropriate loads in determining total overturning effects as discussed in Section 3.8 .

REFERENCES

1. 'Dynamic Effects of Earthquake on Engineering Structures,' Tennessee Valley Authority, Report No. 8-194, August 1939.

2. Hayashi, Satoshi, 'Analysis and Design of Earth Structures and Foundations,' Syllabus for Earthquake Engineering Fundamentals, August 22 through September 2, 1966, Engineering Extension, Department of Engineering, University of California, Los Angeles.

3. Whitman, R. V., 'Analysis of Foundation Vibrations,' Vibration in Civil Engineering 1966, Buttersworth, London.

4. Sequoyah Nuclear Plant Final Safety Analysis Report, Tennessee Valley Authority, Docket Numbers 50-327 and 50-328.

5. Richart, F. E., Jr., J. R. Hall, Jr., R. D. Woods, Vibrations of Soils and Foundations, Prentice-Hall, Incorporated, 1970, New Jersey.

6. N. M. Newmark, 'Design Criteria for Nuclear Reactors Subjected to Earthquake Hazards,' Proceedings, IAEA Panel on Aseismic Design and Testing of Nuclear Facilities, Japan Earthquake Engineering Promotion Society, Tokoyo, May 1967.

7. T. L. Gesinski, 'Fuel Assembly Safety Analysis For Combined Seismic and Loss-of-Coolant Accident,' WCAP-7950, July 1972.

8. E. L. Vogeding, 'Seismic Testing of Electrical and Control Equipment,' WCAP-7817, and Supplement I, December 1971.

9. Gessinki, L. and D. Chaing, 'Safety Analysis of the 17x17 Fuel Assembly for Combined Seismic and Loss-of-Coolant Accident,' WCAP-8288, January 1974. 44

10. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.60 December 1973.

11. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.61, October 1973.

12. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.92, December 1974

3.8.4 Other Category I Structures

The Category I structures other than the primary containment, interior structures, and shield building are listed as follows: 51

1. Auxiliary-Control Building and Associate Structures

    a. Control Bay Portion

    b. Auxiliary Building Portion

    c. Waste Packaging Structure

    d. Condensate Demineralizer Waste Evaporator Structure Portion 5

    e. Additional Equipment Building Portion

2. Diesel-Generator Building

3. Category I Water Tanks and Pipe Tunnels 38

4. Class IE Electrical Systems Structures

5. North Steam Valve Room

6. Intake Pumping Station and Retaining Walls

7. Miscellaneous ERCW Structures

8. Additional Diesel Generator Building

3.8.4.1 Description of the Structures

3.8.4.1.1 Auxiliary-Control Building

This building and associate structures are multistory reinforced concrete structures which provide housing for the engineered 5 safety feature systems, etc., which are necessary to the two reactor units. Certain floors in the control bay, the Condensate Demineralizer Waste Evaporator Structure, and the roof of the fuel handling ing bay are supported by structural steel framing. 38 Refer to Figures 3.8.4-1 through 3.8.4-9 for the general layout and configuration of the structure.

Control Bay Portion

Structure

The control bay portion is a multistory reinforced concrete structure that is built integrally with the Auxiliary Building portion as shown in Figure 3.8.4-8. The structure is separated from the Turbine Building by a 2-inch expansion joint filled

3.8.4.1.7 Miscellaneous ERCW Structures

38

Slabs and Beams Supporting ERCW Pipes

At the Intake Pumping Station the ERCW pipes are supported on a reinforced concrete slab. The slab is approximately 8' below grade and 50' above Bedrock. The slab is supported by a bracket on the Pumping Station wall, bearing piles, and undisturbed earth. Structural separation from the Pumping Station is provided by 1/2' of expansion joint material. The slab is shown in Figure 3.8.4-56. 44

The ERCW pipes at the Diesel Generator Building are encased in concrete beams for support. The pipes are separated from the beam by insulation and the beam is separated from the Diesel Generator Building by expansion joint material. The beams are supported by brackets on the Diesel Generator Building and by Class A backfill. The beams are shown in Figure 3.8.4-56b.

Discharge Overflow Structure

The discharge overflow structure is a reinforced concrete box-type structure supported on granular fill material placed over basal gravel. The function of the discharge overflow structure is to provide for the normal flow rate discharge of the ERCW system without unacceptable back pressure if the downstream pipes are blocked and to permit flow to the holding pond under normal conditions. The structural outline is shown in Figure 3.8.4-46a. 42 44

Standpipe Structures

The two standpipe structures are mass reinforced concrete structures placed on firm granular material. The structures have backfill on four sides for the first 8 feet of height and extend 17 feet above grade. The function of these structures is to protect the standpipes from Tornado-Generated missiles. The structures are shown in Figure 3.8.4-56a.

Valve Covers

These structures consist of reinforced concrete slabs covering the valves in the ERCW pipes. The slabs are located at grade above the pipes and are supported by either the missile protection slab and/or backfill. The slabs have small openings with precast concrete covers above each valve stem. The openings in the missile protecting valve covers provide immediate access to the valves in an emergency. The structures are shown in Figure 3.8.4-56c.

3.8.4.1.8 Additional Diesel Generator Building

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3.8

INSERT D

COMPUTED ______ DATE ______

CHECKED ______ DATE ______

3.8.4.1.9 ADDITIONAL DIESEL GENERATOR BUILDING

THE ADDITIONAL DIESEL GENERATOR BUILDING IS LOCATED 349.25 FEET NORTH OF THE CENTERLINE OF THE REACTOR BUILDINGS AND 54.50 FEET WEST OF THE CENTERLINE OF THE UNIT 1 REACTOR BUILDING. IT IS A TWO-STORY RECTANGULAR, REINFORCED CONCRETE, BOX-TYPE STRUCTURE WHICH HOUSES THE ADDITIONAL DIESEL GENERATOR Unit AND ITS AUXILIARY EQUIPMENT. THE BUILDING IS 96 FEET LONG BY 53 FEET WIDE AND IS SUPPORTED ENTIRELY ON END BEARING STRUCTURAL STEEL H-PILES AS SHOWN IN FIGURE 3.8.4-72. THE BASE SLAB IS 12 FEET THICK WITH THE FINISHED FLOOR AT ELEVATION 742.0. THE DIESEL FUEL STORAGE TANKS ARE EMBEDDED IN THE BASE SLAB. FOR GENERAL LAYOUT AND CONFIGURATION OF THE BUILDING SEE FIGURES 3.8.4-73 THROUGH 3.8.4-80.

ADDITIONAL DIESEL GENERATOR BUILDING DOORS AND BULKHEADS

THE TWO LARGE DOOR OPENINGS, SHOWN IN FIGURES 3.84-74 AND 75, IN THE NORTH AND EAST EXTERIOR WALLS OF THE BUILDING AT ELEVATION 742.0, PROVIDE FOR PASSAGE OF LARGE TOOLS AND REPAIR PARTS FOR THE ADDITIONAL DIESEL GENERATOR UNIT AND ITS AUXILIARY EQUIPMENT. REMOVABLE MISSILE BARRIERS OF PRECAST, STACKABLE CONCRETE SECTIONS, ARE INSTALLED AND BOLTED INTO POSITION IN FRONT OF THESE DOORWAYS TO PROTECT SAFETY-RELATED EQUIPMENT FROM TORNADO WIND AND MISSILE THESE MISSILE BARRIERS ALSO FORM PART OF THE SECURITY SYSTEM BY PREVENTING UNAUTHORIZED ENTRY INTO THE BUILDING THROUGH THESE DOORS. DUE TO THE PRESENSE OF THE PRECAST CONCRETE MISSILE BARRIERS IN FRONT OF THE DOORWAYS, THE EQUIPMENT DOORS DO NOT NEED TO FUNCTION AS MISSILE BARRIERS AND THEREFORE STANDARD DOUBLE DOORS ARE USED. THE PRECAST CONCRETE MISSILE BARRIERS WILL BE REMOVED ONLY FOR MAJOR REPAIR OF THE DIESEL GENERATOR.

3.8.4.2 Applicable Codes, Standards, and Specifications

Unless otherwise indicated in the FSAR, the design and construction of the Category I structures other than the primary containment and interior structures are based upon the appropriate sections of the following codes, standards, and specifications. Modifications to these codes, standards, and specifications are made where necessary to meet the specific requirements of the structures. These modifications are noted in Sections 3.8.4.3, 3.8.4.4, and 3.8.4.6. Where date of edition, copyright, or addendum is specified, earlier versions of the listed documents were not used. In some instances, later revisions of the listed documents were used where design safety was not compromised. 47

3.8.4.2.1 List of Documents

1. American Concrete Institute (ACI)

ACI 315-74	Manual of Standard Practice for Detailing Reinforced Concrete Structures
ACI 318-63	Building Code Requirements for Reinforced Concrete. (See Section 3.8.4.2.2 for basis for use of this section.)
ACI 318-71	Building Code Requirements for Reinforced Concrete
ACI 347-68	Recommended Practice for Concrete Formwork
ACI 305-72	Recommended Practice for Hot Weather Concreting
ACI 211.1-70	Recommended Practice for Selecting Proportions for Normal Weight Concrete
ACI 304-73	Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete

2. American Institute of Steel Construction (AISC)

'Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings,' adopted February 12, 1969, as amended through June 12, 1974. 44

ACI 349-76 Code Requirements for Nuclear Safety Related Concrete Structures, Appendix C only

13. TVA Construction Specifications

G-2 TVA General Construction Specification for Plain and Reinforced Concrete

G-9 TVA General Construction Specification for Rolled Earthfill for Dams and Power Plants

G-29 TVA General Construction Specification - Process Specification for Welding, Heat Treatment

G-30 TVA General Construction Specification - Fly Ash for Use As An Admixture in Concrete

G-32 TVA General Construction Specification - Bolt Anchors Set in Hardened Concrete.

G-42 TVA General Construction Specification for Preparation of Concrete Surfaces for Special Coatings for Nuclear Plants

14. TVA Topical Reports TDA-TR-1 Pipe Whip Criteria, 1973. TVA-TR78-4 Design of Structures for Missle Impact.

15. National Electrical Manufacturers Association, Motor and Generator Standards MG-1, 1970 Edition.

16. Structural Engineers Association of California, "Recommended Lateral Force Requirements and Commentary," 1968 Edition.

17. National Fire Protection Code (NFPA) 30.

3.8.4.2.2 Basis for Use of the 1963 Edition of ACI 318

The reason for using the 1963 edition of the ACI 318 Code was that much of the Watts Bar Plant was a duplicate of the Sequoyah Plant, for which structures were designed using the 1963 edition. On that basis, design computations for the Sequoyah plant were the design computations for the Watts Bar plant.

In some instances, structures could not be duplicated and new design computations were prepared for these structures with the designs in accordance with the ACI 318-71 Code. Within duplicate structures where loading changes required investigation of the Sequoyah design for an element of the structure, and the result was a change in member size or reinforcement requirement, then the redesign for the member was in accordance with the ACI 318-71 Code. 39

The duplicate structures are as follows:

fy = 60,000 psi

No. 11 bar in tension, top bar

Bar spacing, 6 inches to 17 inches

	318-63 W. S. Design	318-71 Alt. Sect. 8.10	
A_s Provided Equals That Required By Computation			38 49
Less than 1/2 bars spliced at a given section	102 in.	99 in.	38
More than 1/2 bars spliced at a given section	Not specified TVA practice 1.2x102=122 in.	129 in.	49
A_s Provided Equals Twice That Required By Computation			
Less than 3/4 bars spliced at a given section	102 in.	76 in.	
More than 3/4 bars spliced at a given section	102 in.	99 in.	

3.8.4.3 Loads and Loading Combinations

3.8.4.3.1 Description of Loads

See Tables 3.8.4-1 through 3.8.4-2~~X~~2 for the loads for other Category I structures. Other Category I structures are subject to the same natural phenomena and basic dead, live, and earth pressure loading as described for the Shield Building in Section 3.8.1.3. In addition to active earth pressure loading described in Section 3.8.1.3, the other Category I structures are designed for at rest and passive earth pressures where applicable. 47 51 42

Construction loads differ for the Auxiliary Building because of the multistory effect of shoring from one floor to the next and the construction crane loading on the Control Building portion.

The maximum temperature gradient for walls above grade with exterior exposure is the same as the normal operating temperature gradient of the Shield Building. The spent fuel pit and fuel transfer canal require additional temperature considerations. Under accident conditions the water was assumed to reach 212° F in 8 hours with the inside building temperature initially at 60° F. The normal temperature of the water in the fuel pit and canal is 120° F.

Hydrostatic pressure loads in the fuel pit and canal vary with water levels in the pit, cask loading area, and canal. The cask loading area and canal may be emptied.

The wind and tornado loading are described in Section 3.3. Blowout panels are necessary to restrict the tornado generated pressure differential to 100 psf above the El. 757.0 floor in the Auxiliary Building as shown between column lines t and y, and A-5 and A-11 in Figure 3.8.4-4 and 3.8.4-5. 47

The live load associated with supports and restraint anchorages for cable trays, piping system, and other fastenings to interior shielding walls was restricted to a maximum of 20 pounds per square foot over the face of the wall.

A 1730-psf surcharge loading was applied to the A-1 and A-15 line walls as a construction loading in the Auxiliary Building.

3.8.4.3.2 <u>Load Combinations and Allowable Stresses</u>

See Tables 3.8.4-1 through 3.8.4-2~~X~~2 for the loading combinations and allowable stresses. 51

The normal allowable stresses of ACI 318-63 and ACI 318-71 were used for the basic loading combinations of dead, live, earth pressure, hydrostatic ground water to elevation 710 (or full pool water levels in the spent fuel pit) and effects of normal temperature gradients.

For additional loads such as induced moments or shears resulting from Operating Basis Earthquake, accident pressure loading caused by a LOCA or steam pipe rupture and thermal effects corresponding to the accident condition, a 25 percent increase in steel stress was allowed with concrete stresses restricted to normal allowables.

For construction loading instead of normal live loading or for flood water to elevation 724.4 a 35 percent increase in both steel and concrete stresses was allowed.

For the combination of the basic loads with Safe Shutdown Earthquake effects, or tornado wind loads and associated missiles, or maximum possible flood loads, or impact loadings from jet impingement or jet loading on pipe restraints in conjunction with accident pressures a 67 percent increase in concrete stresses was allowed with steel stresses allowed to reach 0.9 of yield.

The maximum lateral forces generated by the Safe Shutdown Earthquake are transmitted to the base through shear walls which are designed in accordance with Section 2631 (c) of the "Recommended Lateral Force Requirements and Commentary: of the Seismology Committed, Structural Engineers Association of California, 1968.

3.8.4.4 Design and Analysis Procedures

3.8.4.4.1 Auxiliary-Control Building

Control Bay Portion

This concrete structure was designed in accordance with the ACI Building Code 318-63 using the elastic working stress theory. The loads, loading combinations, and allowable stresses used are as given in Section 3.8.4.3.2.

The control bay was designed as an independent structure. A standard frame analysis was performed on the building in the design of the main structural walls and a separate analysis was performed for each loading combination. The stage to which construction of the building's component walls, slabs, and columns would have progressed by the time of the application of a particular loading was taken into account and reflected accordingly in the model frame. 38

The floor slabs at elevations 708 and 729 were designed by ICES STRUDL-II, Volume I program as flat slabs restrained at the exterior structural walls and supported on concrete columns. At elevation 755 the two exterior bays on both ends of the building were designed by ICES STRUDL-II, Volume II program to resist a break in the main steam lines below. The roof slab was designed as a one-way slab spanning between the walls at column lines n and q as shown in Figure 3.8.4-8. These walls act as shear walls in the event of east-west seismic motion or any other east-west lateral force, with the walls along column lines C1, C3, C11, and C13, as shown in Figure 3.8.4-3 acting as shear walls for north-south lateral forces. The roof slab and floor slabs act as diaphragms. The columns and main structural walls transmit vertical load to the base slab.

For load combinations and allowable stresses for the additional diesel generator building see Table 3.8.4-22 to transfer the reaction of the pile to the wale. The wall was divided into sections and analyzed as a multibraced wall or cantilever wall depending upon the depth of backfill on the wall.

3.8.4.4.7 Miscellaneous ERCW Structures

Slabs and Beams Supporting ERCW Pipes

The slab supporting the ERCW pipes was analyzed by the use of McDonnell-Douglas' ICES Strudl computer program. Support was assumed to be furnished entirely by the bearing piles and the piles were designed for the reaction from the computer analysis. Missile protection is provided by roller compacted concrete above the pipes.

The beam encasing the ERCW pipes are analyzed as simple beams with no support from the soil. The encased pipes are in the tension zone of the beam; therefore, the design is for a rectangular beam with no special consideration given to the embedded pipe for flexure or shear. The concrete encasement is designed for missile penetration. 42

Discharge Overflow Structure

The discharge overflow structure was analyzed assuming it as a series of flat plates. The concept of joint continuity was utilized with the plate analysis by designing the joints for the larger moment from adjacent plates.

Standpipe Structures

The standpipe structures consists of a free standing cantilever supported on a flat slab base on insitu soil. Generally, the structures were considered solid mass concrete and the design was controlled by structural response for missile impact utilizing an elastic analysis. 46

Valve Covers

The function of these structures is solely to protect the ERCW valves from Tornado missiles; therefore, the design was for missile penetration only.

Missile Protection Slabs and Backfill

See Section 3.8.4.1.7

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3.8.4.4.8 ADDITIONAL DIESEL GENERATOR BUILDING

The (measured from top of base slab) building is a 96 foot long by 53 foot wide by 32 foot tall reinforced concrete structure, consisting of a base slab supported by end bearing H-piles, interior floor, roof, and interior and exterior walls. The structure was analyzed as a box-type structure assuming all walls are fixed at the base slab. The building span in the short direction is analyzed using a STRUDL frame program and is designed to withstand all loading conditions assuming a one-way span. In the short direction the interior walls are not considered effective shear walls, but the exterior walls are. Therefore, shear wall and diaphram deflections are considered in the short direction frame analysis. The building span in the long direction is designed using standard plate theory assuming the interior and exterior walls effectively prevent sidesway. The building base slab is a 96 foot long by 55 foot wide by 12 foot thick reinforced concrete slab supported by 154 end-bearing steel H-piles. See Section 3.8.5.5 for design and analysis procedures for the piles and base slab.

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Section 3.8.4.4.8 for Additional DG Bldg

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Base Slab Design

The base slab is pile supported. The slab was designed for a uniform live load except where equipment weights dictated a higher value. Equipment loads due to vibration or earthquake acceleration that were transmitted to the slab from anchor bolts were also taken into consideration. In addition, the slab was designed for hydrostatic pressures.

The base slab is a rectangular cast-in-place reinforced concrete structure with diesel fuel storage tanks embedded in it and is supported by piles bearing on rock.

Roof Slab Design

The roof slab was designed for live, seismic, and tornado loads.

Floor Slab

The floor slab is a poured-in-place reinforced concrete slab designed to carry and transmit the floor loads to the building walls. ~~The~~ slab was designed for a uniform live load.

Exterior Walls

The building was designed for tornado venting. However, the exterior walls were designed for tornado, wind, and seismic loads.

Fuel Oil Storage Tanks

The steel liner serves no other function except to maintain leaktightness and, therefore, was designed in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Division I. In addition, the liner was designed to prevent buckling of the steel shell due to the following external loads.

a. Hydrostatic pressure from underground water.
b. Shrinkage of the concrete encasement during construction.
c. Expansion or contraction due to temperature differentials.

For flammable liquids storage requirements the fuel oil storage tanks meet the requirements of the National Fire Protection Association (NFPA) Code 30 which applies to fuel oil storage tanks supplying underground storage of a class II liquid (diesel fuel).

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Equipment Door

The equipment door is composed of a structural steel frame and covered on both sides with a steel-skin plate.

The removable Precast concrete missile barrier bulkheads are placed in front of the equipment doors to provide protection from tornado-generated missiles, which are discussed in Section 3.8.4.1.9. In establishing the required concrete thickness for these missile barriers, no consideration was given to the equipment [illegible] and these barriers are designed to absorb the full missile [illegible]

Allowable Settlement

The building was designed to accommodate a settlement of 2 inches, with a differential settlement of 1 inch over a 96-foot structure length.

End-Bearing Steel H-Piles

The piles were designed to withstand and transmit to rock the effects of the design loads and conditions.

Seismic Analysis

The structure was analyzed for the effects of the operating basis earthquake (OBE) and the safe shutdown earthquake (SSE) as described in Section 3.7.2.1.1.

3.8.4.5 Structural Acceptance Criteria

3.8.4.5.1 Concrete

The Category I structures were proportioned to maintain elastic behavior and stresses within stress allowables when subject to the loading combinations of Section 3.8.4.3.

A maximum shear stress from the Safe Shutdown Earthquake of 230 psi occurs at the base of the south wall of the Diesel Generator Building. Considering only those wall portions with height to depth ratios of less than one, this is less than 91 percent of the allowable.

The stresses in shear walls parallel to the direction of the lateral earthquake forces in the Auxiliary Building are as follows:

Elevation	Maximum Calculated Stress Safe Shutdown Earthquake*		Allowable Stresses (psi)
	N-S	E-W	
692-713	116	232	250
713-737	134	198	250
737-757	144	200	250
757-772	112	150	250
772-786	94	132	250
786-801	152	192	250
Above 801	120	232	250

* Stresses for the Operating basis earthquake are one-half these tabulated values.

~~Stresses for operating basis earthquake are one-half of those tabulated.~~

Earthquake shear stresses were insignificant in all other structures.

Most Category I structures are essentially low profile box structures with height to base ratios less than 1.0 and a high factor of safety against sliding or overturning under the most severe loading conditions. Those structures with height to base ratios greater than 1 are designed with adequate factors of safety applied to stability. In addition, all structures are designed to flood or have sufficient weight to prevent flotation under maximum flood conditions.

For consideration of sliding, overturning, and floatation of the additional diesel generator building see the loading combinations and minimum factor of safety in Table 3.8.4-22.

3.8.4.5.2 Structural Steel

Structural steel and welds are designed in accordance with AISC "Manual of Steel Construction," Seventh Edition, for Case I loading condition so that the stress in the members and connections do not exceed the allowable stress criteria as set forth in the February 1969 AISC "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings," as amended through June 12, 1974. For the factor of safety of these allowable stresses with respect to specified minimum yield point of the material used, see Section 1.5 of "Commentary on the Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings." Both specifications and commentary and included in the AISC "Manual of Steel Construction."

For Case II loading condition the actual stresses do not exceed the allowable stresses as set forth in Table 3.8.4-2. The allowable stresses for Case II loading have a minimum factor of safety of 1.11 based on the specified minimum yield point of the material used.

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3.8.4.5.3 Miscellaneous Components of the Auxiliary Building

Control Room Shield Doors

Allowable stresses for all load combinations used for the various parts of the door and dogs are given in Table 3.8.4-3. For normal load conditions the allowable stresses provide a safety factor of 2 to 1 on yield for structural parts and 5 to 1 on ultimate for mechanical parts. For the limiting condition of safe shutdown earthquake (SSE), stresses do not exceed 0.9 yield.

Watertight Equipment Hatch Covers

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THE ADDITIONAL DIESEL GENERATOR BUILDING STRUCTURAL STEEL WAS PROPORTIONED TO MEET THE APPLICABLE CODES LISTED IN SECTION 3.8.4.2 AND LOAD COMBINATIONS LISTED IN 3.8.4.3.

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3.8.4.5.5 Diesel Generator Building Doors and Bulkheads

Load combinations and allowable stresses for all combinations are given in Table 3.8.4-13. For missile impact, yield point of material will be exceeded and the member practically deform. For normal load condition, the allowable stresses provide safety factors of 2 to 1 on yield for structural parts and 5 to 1 on ultimate for mechanical parts. For limiting conditions, except for missile impact, stresses do not exceed 0.9 yield. 51

3.8.4.6 Materials, Quality Control, and Special Construction Techniques

General

See Section 3.8.1.6.

3.8.4.6.1 Materials

See Section 3.8.1.6.1.

Insert 3.8F.6

3.8.4.6.2 Quality Control

Concrete production and testing were as in Section 3.8.1.6.2.

In addition to the 4000-psi-at-28-days mix discussed in Section 3.8.1.6.2, a 3000-psi-at-28-days mix, a 3000-psi-at-90-days mix, a 5000-psi-at-28-days mix, and a 4000-psi-at-90-days mix were used. Test results were in full conformance with specifications. 42

Testing of reinforcing steel and cadweld splices was as in Section 3.8.1.6.2.

The control room shield doors, watertight equipment hatch covers, railway access hatch covers, railroad access doors, equipment hatch doors and sleeves, manways in the RHR sump valve room, and the pressure confining personnel doors were designed and erected by TVA in accordance with TVA's quality assurance program. Design and fabrication by the contractor were in accordance with the contractor's quality assurance program which was reviewed and approved by TVA's design engineers. The contractor's quality assurance program covers the criteria in Appendix B of 10CFR50.

3.8.4.5.6 Additional Diesel Generator Building Missle Barriers

Design of missle barriers for the additional diesel generator building is discussed in Section 3.5.3.1

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For the additional diesel generator building the following materials were used:

Structural Steel

Rolled shapes, plates, and bars meet Specification ASTM A 36. Fabricated high-strength steel meets Specificaton ASTM A 572 and bolting meets Specification ASTM A 325 or A 490. Anchor bolts meet ASTM A 307 or A 36 steel.

Reinforcing Steel

The yield strength of reinforcing steel used in the building is 60,000 lb/in^2 (ASTM A 615, grade 60) or greater.

Concrete

The compressive strength of concrete is 3000 lb/in^2 or greater.

Fabrication procedures such as welding and nondestructive testing were included in appendices to the contractor's quality assurance program.

ASTM standards were used for all material specifications and certified mill test reports were provided by the contractor for materials used for all load-carrying members. 47

The manufacturer certified QA standards were followed in the construction of the fuel pool gates. 51

3.8.4.6.3 Special Construction Techniques

No special construction techniques were used, except for the fuel oil storage tanks in the additional diesel generator building for these tanks.

3.8.4.7 Testing and Inservice Surveillance Requirements

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3.8.4.7.1 Concrete and Structural Steel Portions of Structures

A program to monitor the settlement of other Category I structures has been instigated as shown in Figures 3.8.4-66 and 3.8.4-67.

3.8.4.7.2 Miscellaneous Components of Auxilliary-Control Building

Control Room Shield Doors

After erection and adjustment the doors were inspected for proper operation of the dogs and free movement on the trolleys.

After the initial inspection, periodic visual inspections of the doors are to be made. Parts inspected during these visual inspections are to include connections to trolleys, structural members for paint deterioration, and dogs.

Watertight Equipment Hatch Covers

After initial inspection, periodic visual inspections of the covers are to be made. A visual inspection will be made of all screws to see that they are securely tightened and that none are missing. The locks will also be inspected to ensure that they remain in place, workable and locked at all times during plant operation. The painted inscriptions on the covers will be inspected for any deterioration. In the event that the hatch covers are removed, an inspection will be made of the gaskets to insure that they are clean and free of any damage or deterioration which would prevent their forming a proper seal. The embedded frames will be inspected to ensure that the mating surfaces are clean and free of foreign material before the covers are reinstalled.

Testing for the steel liners in the fuel oil storage tanks for the additional diesel generator building was accomplished by subjecting them to a standard hydrostatic test in accordance with ASME, Section VIII.

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Attachment for Fuel Oil Storage Tanks in Sec. 3.8.1.6.3

Joint welding procedures used in fabrication of the steel liner were qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX, prior to use by TVA or the fabricator. 100-percent magnetic particle examination of all welds exposed to the contents of the lined vessel was made using properly qualified personnel and in accordance with ASME, Section VIII.

direction. Three closed cells are formed by these walls in combination with the Reactor Building wall. These closed cells are backfilled with a noncompacted crushed stone. The valve room foundation walls are separated from the reactor building foundation and wall by a 2-inch fiberglass expansion joint material.

Diesel Generator Building

The base slab of the Diesel Generator building is discussed in Section 3.8.5.5.2. Based on soils laboratory tests, it could not be assured that the existing material between the top of firm gravel at elevation 713 and base slab was capable of safely supporting the structure. Therefore, this material was removed and replaced with crushed stone fill placed in 4-inch layers and compacted to a minimum of 70 percent relative density. (See Section 2.5.4.5.2.) A slope stability analysis was performed in order to assure stability of the slope below the building.

Refueling Water Storage Tank

The refueling water storage tank foundation is a solid, circular reinforced concrete structure placed on engineered granular fill over firm natural granular soil. The foundation is constructed with shear keys to prevent sliding displacement and with retaining walls to contain a reservoir of borated water after a postulated rupture of the storage tank. The foundation is protected from missiles by a concrete apron.

Discharge Overflow Structure 42

See Section 3.8.4.1.7 for a description of the discharge overflow structure foundation.

Class I Electrical System Manholes and Duct Banks

The manholes and a portion of the duct banks are supported on insitu soil. The duct banks at the intake pumping station are supported on insitu soil, piles, and a bracket on the pumping station wall, see 3.8.4.1.4 for additional information.

ERCW Standpipe Structures

See 3.8.4.1.7 for the standpipe structures.

ERCW Pipe Supporting Slabs and Beams

See 3.8.4.1.7 for a description of the beams and slab.

ERCW Valve Covers

See 3.8.4.1.7 for a description of these structures. 57

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ADDITIONAL DIESEL GENERATOR BUILDING

THE BASE SLAB OF THE ADDITIONAL DIESEL GENERATOR BUILDING IS DISCUSSED IN SECTION 3.8.4.4.8. SIMILAR TO THE DIESEL GENERATOR BUILDING, IT COULD NOT BE ASSURED THAT THE EXISTING SOIL BETWEEN THE TOP OF FIRM GRAVEL AT ELEVATION 713 AND THE BOTTOM OF THE BASE SLAB AT ELEVATION 730 COULD SAFELY SUPPORT THIS STRUCTURE. THEREFORE THE BUILDING WAS SUPPORTED ON END BEARING STEEL H-PILES DRIVEN TO REFUSAL IN SOUND ROCK OR OTHER SUITABLE MATERIAL. FOR ADDITIONAL INFORMATION ON THIS STRUCTURE SEE SECTION 3.8.4.1.8.

3.8.5.2 Applicable codes, Standards, and Specifications

See Sections 3.8.1.2, 3.8.3.2, and 3.8.4.2.

3.8.5.3 Loads and Loading Combinations

The loads and loading combinations are described in Sections 3.8.1.3, 3.8.3.3, and 3.8.4.3.

3.8.5.4 Design and Analysis Procedure

3.8.5.4.1 Primary Containment Foundation

The foundation was analyzed as a slab on a rigid foundation. The slab was analyzed using computer code Gendek 3 Finite Element Analysis of Stiffened Plates.

Maximum tangential and radial moments were obtained using the finite element analysis of the various load combinations. Shear stresses were obtained by conventional analysis for the containment vessel anchorage and major equipment loadings.

3.8.5.4.2 Auxiliary-Control Building

The reinforced concrete base slab of the Auxiliary-Control Building was designed in compliance with the ACI Building Code 318-63. It was analyzed by the ICES STRUDL-II finite element method as a slab on an elastic foundation. In the ICES STRUDL- II program the foundation material was modeled by assigning a vertical spring to each node of the grid system which was used to represent the base slab. The base slab was divided into elements with wall stiffnesses being recognized by introducing flexural rigidity along the wall and torsional rigidity being recognized by including a rotational spring. Superposition of the various loading conditions were used to obtain maximum stresses. Manual calculations gave results for the bending moments which checked reasonably close with those obtained from the ICES STRUDL-II analysis. A standard frame analysis was also performed in order to determine the shearing forces in the slab.

Shear walls fixed to the base slab transmit lateral force to the slab; the base slab itself is keyed and anchored into foundation rock to transmit shear from the structure into the rock.

The 45-inch-thick slab of the waste packaging area was designed for a uniform distribution of base pressure to span as a flat plate between the load bearing walls. Walls were thicker than necessary for structural purposes because of shielding requirements.

For loads and loading combinations on the additional diesel generator building see table 3.8.4-22

Waste Packaging Structure 51

This structure is situated on well-compacted crushed stone backfill above rock and was designed for a normal allowable uniform bearing pressure of 4 kips per square foot and a maximum allowable pressure with 70 percent or more of the base in compression of 8 kips per square foot under maximum overturning forces. Actual calculated bearing pressures were 1.4 ksf for uniform loading and 6.7 ksf with 72 percent of the base in compression for maximum overturning forces.

Diesel Generator Building

The structure is situated as described in Section 3.8.5.1.2. The base slab of the Diesel Generator Building is 9 feet 9 inches thick founded on crushed stone backfill and located above maximum possible flood elevation 740.3. The structure was designed for a normal allowable uniform bearing pressure of 4 kips per square foot and a maximum allowable pressure of 8 kips per square foot under maximum overturning forces. Actual calculated bearing pressures for the Diesel Generator Building were 2.0 kips per square foot for uniform loading and 4.9 kips per square foot for maximum overturning forces with 100 percent of the base in compression. 38

3.8.5.6 Materials, Quality Control, and Special Construction Techniques

General

See Section 3.8.1.6.

3.8.5.6.1 Materials

Concrete and Reinforcing Steel

See Section 3.8.1.6.1

Backfill Materials

Backfill material was taken only from areas designated by the soils investigation program (see Section 2.5.4.5.2) as suitable for backfill material.

Additional Diesel Generator Building

For discussions on this pile supported structure see Section 3.8.4.4.8. Also, no rotational restraint from the piles was considered because the 12 foot thickness of the base slab is so stiff compared to that of the steel H-piles.

4. Component cooling water pumps

These pumps, energized from the diesel generator, start automatically following a loss of normal electrical power. Start/stop controls located outside the control room (as well as being provided inside) will be provided.

5. Instrument air compressors

These compressors start automatically on low air pressure.

6. Reactor containment fan cooler units

Start/stop motor controls with a selector switch will be provided for the fan motors. The controls will be located outside as well as inside the control room. 45

7.4.1.2.3 Diesel Generators

These units start automatically following a loss of normal ac power. However, manual controls for diesel startup ~~will also be~~ ARE provided locally at the diesel generators (as well as in the control room).

IN THE EVENT THAT ANY ONE OF THE FOUR DIESEL GENERATOR UNITS IS INOPERABLE, THE ADDITIONAL DIESEL GENERATOR UNIT CAN BE MANUALLY ALIGNED TO REPLACE THE INOPERABLE UNIT. ONCE THE ADDITIONAL DIESEL GENERATOR UNIT HAS BEEN MANUALLY ALIGNED, IT WILL BE CONTROLLED BY THE CONTROLS (IN THE MAIN CONTROL ROOM) OF THE UNIT BEING REPLACED.

7.4.1.2.4 Valves and Heaters

1. Charging flow control valves

Remote manual control with a selector switch for the charging line flow control valves are provided in the same area as the auxiliary feedwater controls. These controls duplicate functions available in the control room.

2. Letdown orifice isolation valves

Open/close controls with a selector switch for the letdown orifice isolation valves are provided outside the control room. These controls duplicate functions that are inside the control room.

8.0 ELECTRIC POWER

8.1 INTRODUCTION

8.1.1 Utility Grid and Interconnections

The Tennessee Valley Authority (TVA) is a corporation of the United States Government serving the State of Tennessee and parts of six other States in the southeast on the boundaries of Tennessee. TVA is interconnected with electric power companies to the north, west, south, and east of its service area. As shown in Figure 8.1-1, the TVA grid consists of interconnected hydro plants, fossil-fueled plants, combustion turbine plants, and nuclear plants supplying electric energy over a transmission system consisting of various voltages up to 500 kv.

The Watts Bar Nuclear Plant is located 48 miles northeast of Chattanooga, Tennessee, on the west bank of the Tennessee River. The plant is connected into a strong existing transmission grid supplying large load centers. Both nuclear units are connected into TVA's 500-kv transmission system. One unit is connected 52 with three and the other with two 500-kv transmission lines which are integral parts of the 500-kv transmission grid. Normal power for the operation of a nuclear unit is supplied from unit station service transformers when the unit is connected to the transmission system through its main transformer bank. Preferred power is supplied from the existing Watts Bar Hydro 161-kV Switchyard over two radial lines located entirely on TVA property. The Watts Bar Hydro 161-kV Switchyard is 48 interconnected with the TVA power system through six 161-kV tranmission lines, five hydro generators, and four steam generators.

8.1.2 Plant Electrical Power System

The plant electric power system consists of the main generators, the unit station service transformers, the common station service transformers, the diesel generators, the batteries, and the 48 electric distribution system as shown on Figure 8.1-2, 8.1-2A, and 8.1-3. Under normal operating conditions, the main generators supply electrical power through isolated-phase buses to the main step-up transformers and the unit station service transformers located adjacent to the Turbine Building. The primaries of the unit station service transformers are connected to the isolated-phase bus at a point between the generator terminals and the low-voltage connection of the main transformers. During normal operation, station auxiliary power is taken from the main generator through these transformers. During startup and shutdown auxiliary power is supplied from the 161-kv system through the common station service transformers. The standby (onsite) power is supplied by four diesel generators. An additional diesel generator unit (ADGU) has been provided (equivalent to the existing diesel generators) to replace any one of the four existing diesel generator units.

The safety objective for the power system is to furnish adequate electric power to ensure that safety-related loads function in conformance with design criteria and design bases. Major loads on the electric power system having assigned safety related functions are shown in Table 8.1-1.

The safety objective has been accomplished by: (1) establishing design criteria and bases that conform to regulatory documents and accepted design practice, and (2) implementation of these criteria and bases in a manner that assures a system design and a constructed plant which satisfies all safety requirements. The applicable documents governing the design are shown in Section 8.1.5.

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~~Figure 8.1-2 and 8.1-2a depicts the plant distribution system that receives a.c. power from the two nuclear power units, the two independent preferred (offsite) power circuits, and four 4400-kW diesel-generator standby (onsite) power sources and distributes it to both safety-related and nonsafety-related loads in the plant. The two preferred circuits have access to the TVA transmission network which in turn has multiple interties with other transmission networks.~~ 48

The safety-related loads are arranged electrically into four power trains, two for each nuclear unit. Power trains 1A and 2A comprise load group A. Power trains 1B and 2B comprise load group B. Two diesel generators and one load group can provide all safety-related functions to mitigate a LOCA in one unit and safely shutdown the other unit. Each power train of each unit has access to a diesel generator (standby source) and each of the two preferred offsite sources. 52 54

Figure 8.1-3 depicts the vital a.c. and d.c. control power distribution systems that connect four 125V batteries, four battery chargers and eight 120V a.c. uninterruptable power systems (UPS) with their respective safety-related loads. The 125V d.c. distribution system is a safety-related system which receives power from four independent battery chargers and four 125V d.c. batteries and distributes it to safety-related loads of both units. The 120V a.c. distribution system receives power from eight independent UPSs and distributes it to the safety-related loads of both units. These systems are described in Sections 8.2 and 8.3. 48 48

8.1.3 Safety-Related Loads

Major loads requiring electric power to perform their safety-related function are listed in Table 8.1-1.

8.1.4 Design Bases

The design bases for the electric power system are listed below.

Figures 8.1-2 and 8.1-2A depict the plant distribution system that receives AC power from:

a. The two nuclear power units.

b. The two independent preferred (offsite) power circuits, which have access to the TVA transmission network, and in turn have multiple interties with other transmission networks.

c. The four 4400-KW diesel generator standby (onsite) power sources.

d. The 4400-KW additional diesel generator unit, which may be used as a replacement for any one of the four existing diesel generators.

The power received from the above sources is distributed to both safety-related and non-safety-related loads in the plant.

of power) thus a single failure and/or a loss of offsite power does not prevent the safe and orderly shutdown of either unit.

Plant common loads such as emergency gas treatment are supplied from unit 1, channels I and II.

In no case does the sharing inhibit the safe shutdown of one unit while the other unit is experiencing an accident. All shared systems are sized to carry all credible combinations of normal and accident loads. 46

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a. Watts Bar is a two-unit plant.

b. With a single failure (loss of a battery or loss of a diesel generator) in the plant sufficient ESF loads are still automatically available to the accident unit and to safety shutdown the remaining unit. The shared safety systems are designed so that one complete header (train) can shutdown one unit with a design basis accident and the other unit with a concurrent full load rejection. For these events, electric motors driving equipment in the shared systems are connected without regard to which unit has initiated the accident signal. Therefore, a spurious accident signal in the nonaccident unit concurrent with an accident in the other unit will not cause a standby power supply to be overloaded.

c. The most severe DBE is an accident in one unit and a trip of the other unit. Sufficient diesel generator (DG) power is available to attain a safe and orderly shutdown of both units with the loss of one DG unit. Assuming the loss of offsite power, a design basis accident in one unit, and a full load rejection in the other unit, one division of ESF equipment can be used to bring the plant to a safe and orderly cold shutdown. Therefore, the safe shutdown could be achieved with the complete failure of a power train in one unit or even with the complete failure of the same power train (-A or -B) in both units. 52

d. The DG units and the onsite distribution system are arranged in two redundant trains per unit with one C-S D/G that can be manually substituted for any one of the other D/G units. Due to the shared ESF system (example: ERCW) only one DG unit per plant can be taken out for maintenance or tested at a time. With only one DG unit unavailable, this will ensure power is supplied to enough ESF equipment to safety shutdown both units, assuming the loss of offsite power.

e. No interface of the unit operators is required to meet position 2.b. and 2.c.

8.3 ONSITE (STANDBY) POWER SYSTEM

8.3.1 A.C. Power System

The onsite a.c. power system is a Class IE system which consists of: (1) the Standby A.C. Power System, and (2) the 120V Vital A.C. System. The safety function of the Standby Power System is to supply power to permit functioning of components and systems required to assure that (1) fuel design limits and reactor coolant pressure boundary design conditions are not exceeded due to anticipated operational occurrences, and (2) the core is cooled and vital functions are maintained in event of postulated accidents, subject to loss of the Preferred Power System and subject to any single failure in the Standby Power System. The safety function of the 120V Vital A.C. System is to supply power continuously to reactor protection, instrumentation, and control systems; engineered safety features instrumentation and control systems; and other safety-related components and systems, subject to loss of all a.c. power and any single failure within the Vital A.C. System.

8.3.1.1 Description

Standby A.C. Power System

The Standby A.C. Power System is a safety-related system which continuously supplies power for energizing all a.c.-powered electrical devices essential to safety. Power continuity to the 6.9-kV shutdown boards is maintained by switching among the nuclear unit source (the normal source), the preferred (offsite) sources, and the standby (onsite) source. Source selection is accomplished by automatically transferring from the nuclear unit source to the preferred sources to the standby source, in that order. The reverse transfers are manual. The circuits connecting the normal, preferred, and standby sources to the distribution portion of the Standby Power System are shown in A Figure 8.1-2~~X~~. The normal and preferred power circuits and the transfer scheme used to effect the source switching for these circuits is further discussed in Section 8.2. 48

System Structure

Insert 8C ~~The Standby AC auxiliary power distribution system consists of the Class 1E diesel generators, the 6.9 kV shutdown boards, the 480V shutdown boards, and all motor control centers supplied by the 480V shutdown boards for both units.~~ It is shown on Figure 8.1-2~~X~~A. 52

The Standby Power System is divided into two redundant load groups. Each load group is composed of two power trains (train - 1A and 2A; train - 1B and 2B) and supplies power 48

458

The standby AC auxiliary power distribution system consists of the following:

a. The four Class 1E existing diesel generator units (EDGU).

b. The 6.9-kV shutdown boards.

c. The 480-V shutdown boards.

d. All the motor control centers supplied by the 480-V shutdown boards for both units.

e. The Class 1E additional diesel generator unit (ADGU) when it is replacing one of the EDGU.

f. The 6.9-kV diesel generator board C-S.

g. The 480-V diesel auxiliary supply boards A and B.

h. The 480-V diesel auxiliary board C1-S and C2-S.

to all plant safety-related equipment. The power train assignment for safety-related electrical boards is indicated by 48 use of a -A or -B suffix following its designation on all drawings and documents. Loads supplied from these boards are safety-related unless designated on the single line drawings with a triangle symbol. Equipment shown on schematic drawings is 48 safety-related when designated with a train assignment of A or B. Nonsafety-related loads are also supplied from the Standby Power 52 System through Class IE breakers.

Physical Arrangement of Components

The boards, motor control centers, and transformers comprising the system are arranged to provide physical independence and electrical separations between power trains necessary for eliminating credible common mode failures. The power train assignment for safety-related electrical equipment is indicated by use of an -A or -B suffix following its designation on all drawings and documents.

The specific arrangements of these major components are described as follows:

Reference: Figures 8.3-1 through 8.3-4.

Diesel Generators

The physical arrangement of the ~~four~~ five diesel generators and all support equipment provides physical independence by isolation as indicated in Figure 8.3-1 and 8.3-1A. Each diesel generator and its 52 associated support equipment is separated from all others by missile and fire barrier type walls. The additional diesel generator unit (ADGU) is located in a ~~the~~ ADGU building which is seperate from the other four diesel generators.

Insert 8D

6900-Volt Shutdown Boards 1A-A, 1B-B, 2A-A, and 2B-B

These boards are located in the Auxiliary Building at elevation 48 757.0. They are arranged electrically into four power trains (2 per unit) with two boards associated with each load group and each unit. The boards comprising load group A are located in the Unit 1 area and those of load group B are located in the Unit 2 area. The load group A boards are separated from the load group B boards by an 8-inch reinforced concrete wall extended to the 52 ceiling. The minimum distance between load group A and load group B boards is 8 feet 11-1/2 inches. The two boards associated with load group A or load group B are separated from each other by a distance of 19 feet 9 inches.

6900-480-Volt Shutdown Board Transformers 1A1-A, 1A-A, 1A2-A, 1B1-B, 1B-B, 1B2-B, 2A1-A, 2A-A, 2A2-A, 2B1-B, 2B-B, and 2B2-B

These transformers are located in the Auxiliary Building at

The ADGU which has the same capacity as any one of the existing diesel generator units (EDGU), 4400-KW, may serve as a replacement of any one of the four EDGU. It has no train designation until it has been manually aligned (electrically, mechanically, etc.) to replace an EDGU. Then it will assume the train requirements of the unit being replaced and shall be considered to be a part of the engineered safeguards. (See Figures 8.3-24A and 8.3-24B.)

The manual electrical alignment sequence is as follows:

a. Control and annunciation cables - The control and annunciation switching required to substitute the ADGU for a trained DGU will require the transfer of the control and annunciation cables at two isolation points. (1) At the disabled DGU's control and annunciator distribution panels located in the diesel generator building, the control and annunciation cables required for operation of the disabled DGU will be ~~switched~~ed to those cables required for the operation of the ADGU.

(2) In the ADGU building, the ADGU's control and annunciation cables are connected to the disabled DGU train control and annunciation connectors. The connectors are keyed to assure that each plug can only be plugged into the correct receptacle. This design provides separation of trained equipment by energizing only one set of ADGU control connectors at a time and providing two isolation points to preclude a single failure from affecting more than one DGU (see Figures 8.3-14A through 8.3-29A).

When the control and annunciation ~~connections~~ have been made, the ADGU may be controlled by the controls of the EDGU it replaced in the main control room. This will allow ~~local manual~~, remote, and remote automatic starting of the ADGU.

Panels located in the ADGU ~~building contain~~ all of the controls necessary to permit operation and testing of the ADGU locally. (See Figures 8.3-14A through 8.3-29A.)

b. Disconnect and transfer - The disabled EDGU 6.9-kV disconnect switch is opened, and then the transfer switch to the ADGU is closed. The disconnect and transfer switches are Class 1E qualified. (See Figure 8.1-2A.)

c. Feeder breaker - The 6.9-kV feeder breaker is racked into the compartment of the 6.9-kV DG board C-S, for the disabled EDGU, and closed.

With the controls, annunciators, transfer switches, and circuit breaker aligned as described, the ADGU is an exact electrical functional replacement for the disabled EDGU.

elevation 772.0. Four rooms have been provided so that the transformers associated with power trains A and B of both nuclear units are in separate rooms. The walls isolating these rooms are made of 8-inch reinforced concrete and extend to the ceiling. The three transformers associated with one train of each unit are located in one of the four rooms. (Figure 8.3-2) 52 52

Insert 8E →

480-Volt Shutdown Boards 1A1-A, 1A2-A, 1B1-B, 1B2-B, 2A1-A, 2A2-A, 2B1-B, and 2B2-B

Separate rooms for the 1A, 2A, 1B and 2B boards and their respective 480-volt Control/Auxiliary Building Vent boards are located in the Auxiliary Building at elevation 757.0. (Figure 8.3-3) 48 52

480-Volt Reactor MOV Boards 1A1-A, 1A2-A, 1B1-B, 1B2-B, 2A1-A, 2A2-A, 2B1-B, and 2B2-B

These boards are located in the Auxiliary Building at elevation 772.0. They are located in separate rooms on a power train basis and are located in the same room as the reactor vent boards associated with the same unit and train. The 480-volt Auxiliary Building common board is in the room with MOV boards 1A1-A and 1A2-2. The isolating walls of these rooms are constructed of 8-inch reinforced concrete extended to the ceiling. (Figure 8.3-2) 52 30

480-Volt Reactor Vent Boards 1A-A, 1B-B, 2A-A, and 2B-B

These boards are located in the rooms with the 480-volt reactor MOV boards described above. (Figure 8.3-2) 52

480-Volt Control/Auxiliary Building Vent Boards 1A1-A, 1A2-A, 1B1-B, 1B2-B, 2A1-A, 2A2-A, 2B1-B, and 2B2-B

These boards are located in the rooms with the 480-volt shutdown boards described above. (Figure 8.3-3)

480-Volt Diesel Auxiliary Boards 1A1-A, 1A2-A, 1B1-B, 1B2-B, 2A1-A, 2A2-A, 2B1-B, ~~and~~ 2B2-B, C1-S and C2-S

These boards are located in the diesel generator building at elevation ~~760~~. They are located in separate rooms on a unit and train basis. The isolating walls of the rooms are reinforced, poured-in-place concrete. Interconnecting doorways are protected by self-closing fire-resistanct doors. (Figure 8.3-4)

Insert 8F →

6900-480-Volt Pressurizer Heater Transformers 1A-A, 1B-B, 1C, 1D, 2A-A, 2B-B, 2C, and 2D

These transformers are located in the Auxiliary Building at elevation 782.0. Transformers 1A-A, 2A-A, 1D and 2D are located

760.5 except for boards C1-S and C2-S which are located in the ADGU building on elevation 760.

6900-Volt Diesel Generator Board (C-S)

This board is located in the ADGU building at elevation 742'-0" and is connected to the ADGU through a normally closed breaker at compartment B.

Compartments F, H, J, and E of this board feed the existing DGU transfer switches. Only one breaker for these four compartments is used, thus allowing the ADGU to be connected to one transfer switch at any one time when it is being substituted for an EDGU (see FSAR Figure 8.3-24B).

480-V Diesel Auxiliary Supply Board C-S

This board is located in the ADGU building at elevation 760'-0". It has two buses, bus A and bus B, separated by a bus tie breaker (TB).

For normal operation power is supplied from the 6.9-kV common board A panel 15.

~~Upon loss of normal supply voltage~~ and with the ADGU aligned to replace any disabled EDGU, the ADGU will supply power to Class 1E loads required to support the ADGU in its operating mode. (See Figures 8.3-30A through 8.3-31C.)

UPON LOSS OF OFFSITE POWER

The events which initiate a safety injection signal are discussed in Chapter 7.

For test and exercise purposes, a diesel generator may be manually paralleled with a normal or preferred power source. A loss of offsite power or a safety injection signal will automatically override the manual controls and establish the appropriate alignment. 48

The diesel can be started by manually operated emergency start switches located on the unit control board in the Main Control Room and Auxiliary Control Room. (The diesel also has a local manual start switch as well as remote start from the Main Control Room for test purposes). Automatic starting is from an accident signal or a loss of voltage or degraded voltage signal. All automatic and emergency start signals operate to deenergize a normally energized control circuit. These signals also operate a lockout relay that removes all manually operated stop signals except emergency stop and all protective relaying on the generator except generator differential. The lockout relay must be manually reset TO RETURN THE DG TO ITS STANDBY ALIGNMENT at the diesel generator relay panel in the diesel building OR THE ADGU BUILDING. A local idle start switch is provided to start and run the engine at idle speed for durations of unloaded operation. During this type operation any emergency signal will cause the engine to go to full speed and complete the emergency start ~~circuit.~~ SEQUENCE. 48

Internal combustion engines operate most reliably at the rating for which they are designed. At extended light load operation, lube oil can be expected to accumulate in the exhaust system. 44

Manufacturer's recommendations are that the diesel generators not be run for extended periods of time at less than 50% of continuous rated load. For all situations, TVA has loads continuously available to the operator that exceed 50% of the continuous rated load.

The manufacturer has indicated that the diesel engines have been tested for no-load operation for four hours.

After four hours of operation at less than 30-percent load, the diesel generator is run at a minimum of 50-percent load for at least 30 minutes. 55

After an accident situation when the diesel generator has run for an extended period of time at low or no-loads, the load is TO BE gradually increased until the exhaust smoke is approximately twice as dense as normal. The increasing load is then stopped until the smoke clears. This procedure is repeated until full load can be carried with a clear exhaust. 52

At synchronous speed and loads less than 20-percent (20%) of rated, a 3000 hour ~~ac~~cumulative time limit has been placed on turbochargers. Between 20 percent (20%) and 50 percent (50%) 48 55

load, there is a~~n~~ 6000-hour ~~a~~cumulative time limit. After the 55
time limit has been reached for a particular load level, this
component will be replaced. If a unit is to be run in both the 44
above load ranges, the 3000-hour time limit will be used. 55

In general, after starting, the diesel generators will continue to run until manually shutdown. However, there are protective devices installed to shutdown a diesel generator automatically to prevent heavy damage in the event of a component malfunction. These protective devices are listed below. Protective devices marked with an asterisk (*) are operative at all times while the others are operative only during the test mode of operation. These devices must be manually reset before the engine can be restarted. The status and operability of the trip bypass circuits can be tested and abnormal values of all bypass parameters are alarmed in the Control Room.

<u>Generator</u>
phase balance relay
reverse power relay
voltage restrained overcurrent relay
generator differential relay (*)
overcurrent relay
loss of field relay (THERE IS NO LOSS OF FIELD RELAY IN THE ADGU PROTECTION SCHEME)

<u>Engine</u>
overspeed switch (*)
crankcase pressure switch
low lube oil pressure switch
high water jacket temperature switch

Only one diesel will ever be in the test mode at any one time.
One diesel generator may be stopped by its protective devices
without jeopardizing the safe shutdown of a unit during all 48
postulated design basis events. The protective devices will
prevent excessive damage to a diesel generator and plant
~~operators~~ PERSONNEL will be able to return the diesel generator to its
operating state with a minimum of outage time. ALSO, THE ADDITIONAL 52
DIESEL GENERATOR IS AVAILABLE TO BE SUBSTITUTED.
The diesel can be stopped by manually operated emergency stop switches located in the Main Control Room, Auxiliary Control Room, and on the diesel control panel in the diesel building OR ADGU BUILDING. A manual stop switch is provided in the Main Control Room for stopping the engine under normal conditions~~, such as conclusion of a test or upon return to the nuclear unit or preferred (offsite) power source.~~ Under accident or loss of offsite power conditions this stop switch is automatically disconnected from the stop circuit. The normal stopping of the engine will position the
hydraulic governor at the lower limit and allows the engine to 41
run for 10 minutes at idle speed (450 rpm) before bringing the 48
engine to zero speed. Emergency stopping bypasses this 10 minute
idle speed time and brings the engine directly to zero speed. 52
Should an emergency start signal be initiated during the 10 minute idle speed time of a normal stop condition the engine will

automatically return to synchronous speed and emergency operation.

Diesel engine speed and generator voltage are manually controlled remotely from the Main Control Room only during testing of the unit. An emergency start signal automatically disconnects these manual controls and returns both to automatic operation.

(or ADGU building)

A 'Local-Remote' manual selector switch, located in the diesel generator building, must be in the 'Remote' position for all manual remote control from the control room to be in effect, with the exception of emergency start. Similarly, for the manual controls located in the diesel building to be in effect the switch must be in the 'Local' position. The switch is manually operated from the 'Remote' to the 'Local' position. This operation, however, requires an electrical permissive interlock signal initiated from the Main Control Room. These operations are shown in Figure 8.3-24. 52

Diesel Generator Description

Each diesel-generator set is furnished by Power Systems-A Morrison-Knudsen Division and consists of two 16-cylinder engines (EMD 16-645E4) (or E4B) directly connected to a 6.9-kV Electric Products generator. The continuous rating of each set is 4400 kW at 0.8 power factor, 6.9-kV, 3-phase, and 60 Hz. Each diesel-generator set also has an additional rating of 4840 kW for two hours out of 24. The normal operating speed of the set is 900 rpm. The diesel-generator set uses a tandem arrangement; that is, each set consists of two diesel engines with a generator between them, connected together to form a common shaft. The ~~four~~ five generator sets are physically separated, electrically isolated from each other, and located above the water level of the maximum possible flood (743.5 ft). 48 52

Governor Control of the Diesel-Generator Sets

The governor consists of the following:

(a) Woodward EGB-13P actuator on each engine,

(b) 2301 Computer (reverse biased),

(c) Frequency pickup.

The Woodward EGB-13P actuator used with the 2301 computer is a proportional governor which moves the fuel rack in inverse proportion to the voltage signal from the computer. There is a governor actuator on each engine and they are electrically connected in series so that the loss in signal to one would also be the loss in signal to the other. Based upon the input from the generator, the electronic network sends electric signals to the actuators on the two engines. This signal goes to the coils of each actuator that are connected in series so that each coil sees the same electric signal. The terminal shaft of each actuator will move exactly the same amount for each change in signal. This means that the fuel control shaft movement on each engine will be identical.

Attached to the fuel control shaft through an appropriate linkage is an injector rack for each cylinder which by its position meters the fuel injected into its cylinder. This rack is set with a standard factory gauge so that each cylinder will receive the same amount of fuel. Each injector rack is spring loaded to prevent any single injector that may stick from affecting the remaining racks on that engine.

Two devices produce alarm signals should the two engines of a diesel-generator set receive different amounts of fuel. One of these devices is a synchro device that gives an alarm signal should the difference in the actuator control positions for the two engines exceed a certain tolerance. The other such device is an injector rack limit switch that will initiate an alarm should one engine be on full rack when the other is not.

The mechanical governor is set to control the unit speed at 930 rpm rather than the 900 rpm of the electrical governor. Since the electrical system is reverse biased, a failure in the electrical system would cause the engine speed to increase until it reached the setpoint of the mechanical governor and at that point the mechanical governor would control the engine.

Diesel Generator Auxiliaries

four

The diesel generator auxiliaries are supplied power from the 480V diesel auxiliary boards located in the diesel building on El 760.5 (see Figure 8.3-4). These boards and loads are shown on Figures 8.3-30 and 8.3-31. 52

Insert 8G

Diesel Fuel Oil System

The Diesel Engine Fuel Oil System for each unit consists of a day tank for each engine of the tandem pair holding approximately 550 gallons of fuel and four interconnected tanks embedded in the diesel building foundation floor which hold more than a seven-day supply. 48 Transfer of fuel between the seven-day supply tanks and the engine day tanks is accomplished automatically by a pair of pumps controlled by float-operated switches which sense fuel level in the engine day tanks. One of the pumps is the lead pump with the other pump serving as a backup or supplementary pump (see Figure 8.3-32). 52 Transfer of fuel from outside the diesel building to the seven-day storage tanks is accomplished by manually controlled pumps which can supply fuel

The additional diesel generator unit (ADGU) auxiliaries are powered from the 480-V diesel auxiliary board located in the ADGU building on elevation 760'-6".

This board and loads are shown on Figures 8.3-30A and 8.3-31A.

Diesel Generator Lubrication System

A complete description of the Diesel Generator Lubrication System is given in Section 9.5.7.

Each diesel engine has an oil circulating pump and heater for use while the engine is not running. The oil is continuously circulated and held at a relatively constant temperature while the engine is stopped in anticipation of a required fast start (see Figure 8.3-33 and 8.3-34). 48

Diesel Generator Instrumentation

Instrumentation consists of voltmeters, wattmeters, varmeters, ammeters, and annunciation display panels located in the Main Control Room, Auxiliary Control Room, and locally in the diesel building. The instrumentation is not essential for automatic operation of the diesel.

and the ADGU building

Diesel Generator Control Power

The 125-volt dc diesel-generator battery system is a Class IE system whose function is to provide control power for control and field flashing of the diesel-generator sets.

There are four diesel-generator battery systems (one per diesel-generator set). Each system consists of a battery charger (which supplies the normal steady-state dc loads and maintains the battery in a fully charged state and is capable of recharging the battery from the design minimum discharge of 105 volts dc while supplying the normal steady-state dc loads), a battery (for control and field flashing of the diesel-generator set), and a distribution board (which facilitates the dc loads and provides circuit protection). Each battery system is ungrounded and incorporates ground detection devices. Each battery system is physically and electrically independent (see Section 8.3.2.1.1 and Figure 8.3-46 for physical separation). 48

Insert 8H

Each battery is of the lead-acid type and has 57 cells connected in series and divided into 19 units, every unit having three cells. The battery is a type 3DCU-9, furnished by the C&D

~~Batteries Division of Eltra Corporation, rated at 26 ampere-hours at 60°F for a 30-minute discharge rate.~~ With the battery in the fully charged condition, the battery has the capacity to supply 65 amperes (A) for one minute and 41 amperes for 30 minutes at 60°F when discharged to a minimum terminal voltage of 105 volts. 52 The estimated design loads on the battery, during a loss of ac power, is 48 amperes for two seconds and 12 amperes for 30 minutes. 52 Each battery is normally required to supply loads only during the time interval between loss of normal feed to its charger and the receipt of emergency power to the charger from its respective diesel-generator.

is comprised of

Insert8H

There are five diesel generator battery systems, one per diesel generator. Each system ~~comprises~~ is comprised of a battery, battery charger, distribution center, cabling and cable ways. The battery provides control and field-flash power when the charger ~~or its 480-V supply~~ is unavailable. The charger supplies the normal dc loads, maintains the battery in a fully charged condition, and recharges (480-V ac available) the battery while supplying the required loads regardless of the status of the plant. The batteries are physically and electrically independent. They are ungrounded ~~with~~ and have ground detection instrumentation.

Each battery ~~comprises 19~~ is comprised of nineteen 3-cell lead-acid units which are all series connected. The battery is a type 3DCU-9 manufactured by the C&D Batteries Division of Eltra Corporation. This battery is rated at 100 ampere-hours at the 8-hour rate or 26 ampere-hours at 60°F ~~for a~~ at the 30-minute rate.

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The normal supply of dc current to the battery boards is from the
battery charger. Each charger maintains a floating voltage of
approximately 128 volts on the associated battery board bus (the
battery is continuously connected to this bus also) and is
capable of maintaining 133 volts during an equalizing charge
period (all loads can tolerate the 133-volt equalizing voltage).
~~The charger supplies normal steady-state load demand on the~~
~~battery board and maintains the battery in a charged state. AC~~
~~power for each charger is supplied from its respective 480-volt~~ 46
~~ac, 3-phase diesel generator auxiliary board.~~ Each charger has
access to a normal and alternate ac supply (see Figures 8.3-30
and -31, typical), from the two respective 480-volt ac diesel
generator auxiliary boards. If the normal circuit is
unavailable, the alternate circuit is selected by a manual
transfer. The charger is a solid-state type which converts a
3-phase 480-volt ac input to a nominal 125-volt dc output having
a rated capacity of 20 amperes. Over this output current range
the dc output voltage will vary no more than ± 1.0 percent for a
supply voltage amplitude variation of ± 10 percent and frequency 48
variation of ± 2.0 percent. Some operational features of the
chargers are: (1) an output voltage adjustable over the range of
125 to 133 volts, (2) equalize and float modes of operation (the
charger normally operates in the float mode at 128 volts, but can
be switched to the equalize mode with an output of 133 volts, (3)
a current-limit feature which limits continuous overload
operation to 125 percent of rated output, (4) protective devices
which prevent a failed charger from ~~external overloads~~ loading the battery, (5) 46
metering and alarm circuits to monitor the charger output.

The diesel-generator 125-volt dc control and field flash circuits
are supplied power from their respective dc distribution panels
located in the diesel generator room ~~building on El. 742 (see Figure 8.3-1)~~. A
typical panel and its associated loads is shown on Figure 8.3-55.
Each circuit (including the battery charger input to the panel)
is protected by a thermal-magnetic circuit breaker. The battery
input circuit to the panel is protected by a thermal-magnetic
circuit breaker and a coordinated fuse.

Prior to placing the 125-volt ~~DC~~ dc diesel generator battery system
into service, the system components will be tested to ensure
their proper operation. The diesel-generator batteries will be
preoperationally tested for the following conditions:

1. To verify that the diesel generator battery capacity will
meet the manufacturer's guaranteed performance.

2. To verify that the diesel generator battery system has the 52
ability to supply power before, during, and after loss of the
480-volt ac power supply to the diesel generator battery
charger in the worst case condition.

3. To verify that the battery charger will recharge the diesel generator battery to the nominally fully charged condition while supplying power to the normal control loads.

4. To verify that the diesel generator is able to start, come to speed, flash the generator field, and build up voltages when the diesel generator battery is on equalize charge. 52

In order to verify proper operation of the diesel generator battery system the following items are alarmed in the main control room MCR for each system: low and/or loss of battery charger output voltage, loss of 480-volt ac supply to the battery charger, battery charger output breaker open, blown fuse indication on the battery main fuses, battery main breaker open, battery discharge, battery bus overvoltage, battery system ground detection, and battery system distribution breaker open alarm (with exception of the battery charger tie breaker, which is monitored indirectly via the battery discharge alarm). Also, the MCR alarms are supplemented by the following local meter and alarms: battery and charger output current, battery and charger output voltage, and battery system ground detection. Refer to Figure 8.3-24 for further clarification on these items. 52

Analysis of Diesel Generator 125-Volt DC Control Power System

The diesel generator 125-volt dc control power system is designed to comply with the requirements set forth in GDC 2, 4, 5, 17, and 18. The design also conforms with Regulatory Guides 1.32 and 1.6 and IEEE Std. 308-1971. The following paragraphs discuss each of the requirements: 48

General Design Criteria 2 and 4

The diesel generator 125-volt dc control power system is comprised of ~~four~~ five physically and electrically independent battery systems (see figure 8.3-1). These systems are located in the associated diesel generator room ~~building~~, which is a seismic Category I structure. This structure will provide protection from the effects of tornadoes, tornado missiles, and external floods.

All components of this system are seismically qualified and have been designated as Class 1E equipment. (Refer to Section 3.11, 'Environmental Design of Mechanical and Electrical Equipment'.)

General Design Criteria 5

The ~~four~~ five diesel generator 125-volt dc battery systems are located in individual rooms ~~on elevation 742.0 of the~~ with the associated diesel generator. ~~building. They are located in the room with the diesel generator with which each is associated~~. Each room is equipped with its own heating and ventilating system independent of the other battery rooms and each room is separated from the others by missile and fire barrier-type walls. Also, as stated above, the five ~~four~~ battery systems are electrically independent (one per diesel-generator set). Therefore, the structures, systems, and components important for safe operation ~~of this system~~ are not shared.

General Design Criteria 17

The diesel generator 125-volt dc battery system's design, equipment location, separation, redundancy, and testability enables the standby power system to perform its intended safety function assuming a single failure.

General Design Criteria 18

The diesel generator 125-volt dc battery system is designed to permit appropriate periodic inspection and testing of important areas and features, in order to assess the continuity of the system and the condition of its components. In addition, prior to placing the system into service, it will be preoperationally tested and thereafter periodically tested to ensure the proper operation of all components.

Also, under conditions as close to design as practical, the full operational sequence that requires the battery system's operation will be tested ~~periodically~~ as a part of the diesel generator periodic system testing program. 48

Regulatory Guide 1.32

The diesel generator 125-volt dc battery system's chargers have the capacity to continuously supply all steady-state loads and maintain the batteries in the design maximum charged state or to fully recharge the batteries from the design minimum discharge state within an acceptable time interval, irrespective of the status of the plant during which these demands occur. In addition, a capacity test will be performed periodically on each diesel generator battery system, as recommended by IEEE 450-~~1975.~~ 1980

Regulatory Guide 1.6

Each of the ~~four~~ diesel generator battery systems supply power only to the loads of the diesel generator with ~~to~~ which it is associated ~~with~~. Therefore, the battery systems' safety loads are separated into redundant load groups such that loss of any one group will not prevent the minimum safety functions from being performed. Also, there are no provisions for manually or automatically interconnecting the redundant load groups of this system.

IEEE 308-1971

As discussed in the above paragraphs, the overall system design of the diesel generator 125-volt dc control power system incorporates appropriate functional requirements, redundancy, capability and surveillance in order to comply fully with this criteria. In addition, the system design is such that the battery is immediately available during normal operations and following loss of power from the alternating-current system. Also, each battery has sufficient capacity to meet the power demand and time requirement of each connected load. 48

Prior to placing the 125-volt dc diesel generator battery system into service, the system components will be tested to ensure their proper operation. ~~The diesel generator batteries will be preoperationally tested for the following conditions:~~ 46

1. ~~To verify that the diesel generator battery capacity will meet the manufacturer's guaranteed performance.~~

2. ~~To verify that the diesel generator battery system has the ability to supply power before, during, and after loss of the 480V ac power supply to the diesel generator battery charger in the worst case condition.~~

3. ~~To verify that the battery charger will recharge the diesel generator battery to the nominally fully charged condition while supplying power to the normal control loads.~~

4. ~~To verify that the diesel generator is able to start, come to speed, flash the generator field, and build up voltages when the diesel generator battery is on equalize charge.~~

Diesel Generator Capacity

In compliance with Regulatory Guide 1.9, Rev. 2, the table below compares worst case loading of the diesel generators with their continuous rating and their 2-hour rating. Worst case loading occurs for a simultaneous loss of offsite power and a loss-of-coolant accident on the unit the diesel is associated with. As shown, adequate margin exists, in all cases, between worst case loading and diesel capacity. 48 52

See the discussion under "Diesel Generator Control Power" for a test description.

Diesel Generator Operational Testing

The operational testing of the diesel generator will be accomplished from the diesel generator control panel located in the powerhouse Main Control Room. Full load tests on a unit require that the unit be paralleled with the offsite power system. Should a loss of offsite power occur under these conditions, voltage-restrained overcurrent relays will activate to give a loss of offsite power signal (see Figure 8.3-16). This signal acts to operate the same relays that are used in a normal loss of offsite power condition. These relays act to strip the boards as described under 'Diesel Generator Operation' without disconnecting the diesel generator. The automatic sequencing logic will then reapply the required loads to the standby distribution system as described under 'Diesel Generator Operation.' 52

Fuel Consumption Tests

Each unit was loaded at loads of 1666.5, 3333, and 5000 kW at .8 pf, and the time to consume 100 pounds of fuel was recorded. The duration of the test at each load after temperature stabilization was 1/2 hour with the time to consume 100 pounds of fuel varying from 5 minutes 41 seconds at 1666.5 kW to 2 minutes 28 seconds at 5000 kW.

Transient Tests

Full load transient tests were made to verify that voltage and frequency transient characteristics of the system. Loads of 4400 kW and 4750 kW at 0.8 pf were picked up and dropped three times, each with the following characteristics results:

	Peak Freq. Change %				Peak Voltage Frequency			
Load Change	Unit 1	Unit 2	Unit 3	Unit 4	Unit 1	Unit 2	Unit 3	Unit
+4400 kW	-1.6	-1.3	-1.3	-2.0	-6.0	-6.9	-8.7	-13.0
-4400 kW	+1.6	+2.0	+1.3	+1.8	+6.0	+8.7	+10.4	+10.4
+4750 kW	-1.6	-1.6	-1.3	-2.5	-6.0	-8.7	-8.7	-17.4
-4750 kW	-2.0	+1.6	+2.0	+2.3	_6.0	+8.7	+10.4	+13.0

48

Unit 5
-2.5
+1.3
-3.2
+2.3

Unit 5
-2.1
+2.6
-2.1
+3.0

The assemblies are capable of maintaining containment integrity when subjected to a borated water spray solution of approximately 2000-ppm boron as boric acid and sufficient sodium to bring the pH to 8.0 to 8.5. 52

The penetration assembly is capable of continuous operation at the normal environmental conditions listed below:

Parameter	Inside Containment	Outside Containment
Temperature	30 to 150 F	30 to 125 F
Pressure	-2 to +2 psig	-2 to +2 psig
Relative Humidity	20% to 100%	20% to 100%
Accumulated radiation dose	1 x 10^5 rad	

35 5

Underground Cable Installation

The design and installation of the underground cables conform to the applicable requirements of General Design Criteria 1, 2, 3, 4 and 17 and Section 5.2.1 of IEEE Std. 308. Compliance to the GDC's is discussed in paragraph 3.1. Also, conformance to GDC 17 and IEEE 308 is discussed in Sections 8.2.1.8, 8.3.1.4, and 8.3.1.2.1.

The Class 1E cables between the auxiliary building and the diesel generator building, and the intake pumping station are installed in seismic Category I structures. Figure 3.8.4-37 shows the physical location of the seismic Category I manholes and duct runs (conduit banks); and Figures 3.8.4-38 through 3.8.4-46 show the details of these structures. A description of these manholes and duct runs is given in Section 3.8.4.1.5. 24

The duct runs have been separated or otherwise protected to prevent a common mode failure of the redundant cable system. Some of the manholes have 12-inch concrete divider-walls separating the redundant cables. The manholes have watertight covers and are provided with sump pumps. 2

Cables are designed to operate in wet conditions. The Class 1E cables required to operate the plant in the flooded condition are continuous or provided with a waterproof splice in the potentially submersible sections of the duct runs. Cables have been tested at the factory by the manufacturer according to TVA standard specifications, which includes tests in submerged conditions, such as 3

The Class 1E cables between the diesel generator building and the ADGU building are also installed in Category I structures.

any design basis event. All Class IE electric equipment that has to operate during a flood has been located above maximum possible flood level unless it is designed to operate submerged in water. 29

The Class IE electrical loads are separated into two or more redundant load divisions (channels or trains) of separations. The number of divisions has been determined by the number of independent sources of power required for a given function. The electric equipment that accommodates these redundant divisions is separated by sufficient physical distance or protective barriers. The separation distance has been determined by the severity and location of hazards. The environment in the vicinity of the equipment is controlled or protection provided such that no environmental change or accident will adversely affect the operation of the equipment.

The physical identification of safety-related electrical equipment is in accordance with Section 8.3.1.3.

6900-Volt Equipment

The diesel generators and 6900-volt shutdown boards are designed for a two-division (train A and train B) separation. The 6900-volt equipment is located in seismic Category I structures. The diesel generators are located in the Diesel Generator Building at approximately elevation 742 and have reinforced concrete barriers separating each unit from all other units and have no single credible hazard available that would jeopardize more than one unit. The diesel generator arrangements are shown in Figure 8.3-1. The ADGU is located in the ADGU building at EL 742.0.

The 6900-volt shutdown boards are located in the Auxiliary Building at approximately elevation 757 (see Figure 8.3-3). A minimum distance of 19 feet 9 inches separates shutdown board 1A-A from board 2A-A, and shutdown board 1B-B from 2B-B. An 8-inch reinforced concrete wall extending to the ceiling is used to separate 6900-volt shutdown boards 1A-A and 2A-A from shutdown boards 1B-B and 2B-B. The 6900V diesel generator board C-S is located in the ADGU building at EL 742.0. The ADGU is a seismic Category I structure.

480-Volt Equipment

The 480-volt shutdown boards, 480-volt reactor MOV boards, 480-volt reactor vent boards, and control and auxiliary building vent boards are separated into train A and B groupings by 8-inch reinforced concrete walls extending to the ceiling between associated and non-Class IE cables provides a reliable means of meeting the intent of Regulatory Guide 1.75 to not degrade Class IE cables:

1. A circuit breaker and fuse in series
2. Two circuit breakers in series 52
3. A single fuse

All of the installed protective devices and those added to further protect the associated and Non-Class 1E cables are of a high quality commensurate with their importance to safey.

A majority of the associated circuits analyzed have either two protective devices provided or the calculated short-circuit current is effectively limited to a value less than the conductor's continuous current rating. The remaining eighteen associated circuits have only one protective device. Of these circuits, sixteen are protected by a fuse and two by a circuit breaker. Where practical, an additional protective device has been added to these two circuits protected by a single circuit 48 breaker; otherwise the single circuit breaker is being tested in accordance with the plant's technical specifications.

Non-Class IE power and control cables routed in nondivisional tray, not meeting Regulatory Guide 1.75 separation requirements, similarly have one of the protective schemes described above. Otherwise, the single circuit breaker that protects each non-Class IE power or control cable is tested in accordance with the plant's technical specifications.

There are certain safety-related components which may be powered from one of two redundant divisions (channels or trains) through 52 manual transfer devices. These components include the component cooling system pump C-S, the spent fuel pit pump C-S, and the steam turbine driven auxiliary feedwater pumps 1A-S and 2A-S. The ~~output feeder~~ cables from the transfer device to the component require special separation and are routed in separate raceways ~~conduit(s)~~ with no other circuits with the following exception. Cables with a suffix S may be routed together provided the following two conditions are satisfied: (1) voltage levels are compatible, and (2) circuits are designed such that under any 52 design basis event all cables in the raceway will always be of the same divisions (channel or train) where energized. These circuits are identified by a

In addition, there are certain safety-related components, such as the additional diesel generator unit (ADGU), which are capable of supplying power to redundant divisions (channels or trains) through manual transfer devices

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suffix S added to their respective conduit and cable numbers. The redundant feeder supply cables to the transfer devices have channel or train identification and separation depending on their application.

There are certain safety-related components which are located in a nonseismic structure. The circuits for these components or devices have the following separations. While in a Category I structure, the circuits for these components are routed with train or channel circuits depending on their application. When they leave the Category I structure, these circuits have been separated physically and electrically to reduce the possibility of damage to more than one redundant circuit. 52

The RPS, ESF, and ESAS receive their power from the preferred (offsite) and standby (onsite) sources. The normal power and control circuits from the preferred source are routed in conduits or cable trays separate from the alternate power and control circuits. These circuits are identified by a suffix P or R added to their respective cable numbers. 52

The circuits associated with the standby power sources (Class IE electric systems) are separated into two or more redundant divisions. The circuits between the diesel generators and the 6900-volt shutdown boards are designed for a two division separation (train A and train B).

The feeder circuits from the 125-volt vital battery boards to the control buses in the shutdown boards are separated into four divisions (channels I, II, III, IV). Feeder cables to the control buses in the train A shutdown boards are supplied from battery boards I and III and feeder cables to the control buses in the train B shutdown boards are supplied from battery boards II and IV. The channels I, II, III, and IV vital instrument power systems are supplied from vital battery boards I, II, III, and IV, respectively, and have been physically separated and routed independently from each other. The vital battery board arrangement is shown in Figure 8.1-3. 29

8.3.1.4.4 Fire Detection and Protection in Areas Where Cables are Installed

A hazards evaluation was performed to identify all combustible materials within the plant and the necessary fire suppression capability to control and extinguish fires involving safety related equipment, piping, and cabling has been provided. The threat of exposure fires to safety related equipment, piping, and cabling from permanently installed fire loading will also be considered in the evaluation. All transient fire loads were evaluated in accordance with established administrative procedures and appropriate fire protection is provided. 52

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ALL POWER AND CONTROL CABLES FROM THE ADGU DOWN TO THE FIRST TRANSFER POINT IN THE ADGU BUILDING ARE DESIGNED AS S CABLES AND ARE ROUTED AS SUCH. FOUR CABLE SETS (ONE SET PER EACH EDGU, TWO FOR TRAIN A AND TWO FOR TRAIN B) ARE ROUTED IN CABLE TRAYS IN THE EDGU CONDUIT INTERFACE ROOM (SEE FIGURE 8.3-57 THROUGH 8.3-59) AND ADGU BUILDING AND VIA A CONDUIT BANK BETWEEN THE BUILDINGS. IT IS NOT NECESSARY FOR THESE TRAIN A AND B TRAYS TO BE SEPARATED BY THE MINIMUM DISTANCE SINCE NO MORE THAN ONE TRAIN WILL BE OPERATIONAL AT ANY GIVEN TIME. DURING NORMAL OPERATIONS THE FOUR CABLE SETS ROUTED THROUGH TRAYS A AND B, RESPECTIVELY WILL NOT BE ENERGIZED NOR ELECTRICALLY CONNECTED AT EITHER END. THE ONLY TIME ANY OF THE FOUR CABLE SETS CAN BE ENERGIZED IS AFTER THE ADDITIONAL DIESEL GENERATOR UNIT (ADGU) HAS BEEN MANUALLY ALIGNED TO REPLACE AN EDGU. DURING THIS TIME ONLY ONE OF THE FOUR CABLE SETS (TRAIN A OR B) CAN BE ENERGIZED, DUE TO THE FACT THAT IT IS PHYSICALLY IMPOSSIBLE TO CONNECT MORE THAN ONE OF THE FOUR CABLE SETS SIMULTANIOUSLY.

Fire detection systems are provided generally throughout the plant to annunciate fire alarms and actuate automatic suppression systems where necessary. Detection systems were designed and installed in accordance with applicable portions of NFPA 72A, B, C, D, and E.

Areas with concentrations of electrical cable are being thoroughly evaluated with respect to fuel loading, compartmentation, separation, etc. The concept of the systems approach and defense in depth is being used in the evaluation of these areas as well as throughout all safety related areas of the plant. 52

Generally the areas of the plant containing 'concentration of electrical cables' are as follows:

1. Cable spreading room
2. Some areas of the Auxiliary Building
3. Reactor Building Annulus

A detailed list of these areas will be submitted as a part of the fire protection re-evaluation. Refer to TVA response to Question 010.13.

A carbon dioxide fire protection system with manual control is installed in the following areas: 44

1. Auxiliary instrument room, 52
2. Computer room.

A carbon dioxide system with automatic control is installed in each of the diesel-generator rooms, in each of the auxiliary board rooms, and in the oil pump room of the Diesel Generator Building.

In addition, portable dry chemical and halon fire extinguishers, fixed water suppression and standpipe and hose systems are located throughout the plant. Refer to Section 9.5.1 for a detailed description of the fire protection system. 44

The design of the wall and floor electrical penetration fire stops through fire barriers utilize a separate cable slot (through wall) or cable sleeve (through floor) for each cable tray. The design and installation of these penetration fire stops employ Dow Corning 3-6548 silicone RTV foam (components A and B) as the sealant material over a portion of the length of the cable slot/cable sleeve penetration, and a combination of fire barrier materials. From each side of the wall or floor opening, the cables are separated within the cable slot or cable sleeve using an inorganic fiber. The sealant material is then installed within the cable slot or cable sleeve. The wall opening at each cable slot/tray arrangement, and the cable sleeve

An aqueous film forming foam (AFFF) system is installed in the diesel generator room, the transfer room, the pipe gallery, and the fuel oil transfer room of the ADGU building with a pre-action sprinkler system in the 480 V auxiliary ~~room~~ room three operation conditions for which load values are tabulated. The 135-volt column indicates actual loads expected while the battery charger (set at "float voltage") supplies the battery board load. The 125-volt column represents the actual loads expected with the battery board being supplied from the vital battery (480V ac unavailable), at its normal charged state. The 105-volt column represents the actual loads expected with the battery board being supplied from the vital battery (480-V ac unavailable), at its minimum charged state. The actual load current during an ac power outage will depend on the discharge state of the battery. This subject is also treated in the section on Tests and Inspections. Loads are assigned to the systems according to the loads' divisional requirements. Four divisional loads are assigned to the four channels, two divisional loads are assigned to Channels I or III and II or IV. The loads primarily associated with unit 1 are assigned to Channels I and II while loads primarily associated with unit 2 are assigned to Channels III and IV. Nondivisional loads primarily associated with unit 1 are assigned to Channels I or II. Similarly, nondivisional loads associated with unit 2 are assigned to Channels III or IV. Nondivisional loads that are primarily associated with plant common services are distributed among the four channels. Some loads have a normal and alternate feeder. The normal feeder is from one channel while the alternate feeder is from another channel. These loads are listed in Tables 8.3-19 through 8.3-26. The transfer of the loads between the two feeders is manual and is interlocked to prevent paralleling the redundant power sources. 46

Maximum steady state d.c. loads (during battery recharge following an a.c. outage, the inverters and lighting loads are supplied from a.c. power) for each channel are supplied from a battery charger when it has either normal or standby a.c. power available from the 480-volt shutdown boards. If the normal charger is unavailable, the loads are supplied from either the associated battery or a spare charger which can be manually connected to the battery board. 46

125-Volt Diesel Generator Batteries 1A-A, 1B-B, 2A-A ~~and~~, 2B-B, AND C-S

Reference: Figure 8.3-46

These batteries are located in the diesel generator buildings in the room with the associated diesel. ~~individual rooms on elevation 742.0 of the Diesel Generator Building. They are located in the room with the diesel generator with which each is associated.~~ Each battery is equipped with its own exhaust hood ~~located~~ and ~~directly over it.~~ Each diesel generator room is equipped with its own heating and ventilating system independent of

1. Desired airflows in the ERCW pump area can be maintained during all environmental conditions, including tornadoes, earthquakes, and floods. A structural failure of the grillage roof will not prevent adequate ventilation air from reaching each operating pump.

2. During normal operating conditions, the failure of one of the two ventilation fans in a mechanical equipment room will not result in environmental degradation that will prevent the operation of any safety-related equipment. 52

3. A failure of the electrical equipment room ventilation subsystem will not affect any safety-related components or functions.

The mechanical equipment room contains safety-related as well as non-safety related equipment. Only safety-related equipment will operate during periods of loss of offsite power. Analysis indicate that the safety related equipment alone will not cause unacceptable conditions within the mechanical equipment room; therefore, ventilation is not required. A loss of offsite power will not result in extreme temperatures which would prevent the operation of safety related equipment. 52

9.4.5.1.4 Inspection and Testing Requirements

The ERCW intake pumping station ventilating and heating system is accessible for periodic inspection and testing.

9.4.5.2 Diesel Generator Buildings
9.4.5.2.1 Diesel Generator Building
9.4.5.2.1.1 Design Bases

The diesel generator building ventilating system is required to operate to maintain plant safety in the event of a loss of offsite power due to a natural disaster or plant accident including tornado, earthquake, flood, or fire. The diesel units are redundant and are each served by a separate 100 percent redundant ventilation system. Each ventilation system maintains a proper environment for the operation of safety-related components.

Each diesel engine room ventilation subsystem consists of two room exhaust fans and one generator and electrical panel cooling fan for a total of three fans. 52

One diesel generator exhaust fan along with the cooling fan will automatically start upon diesel startup. The second exhaust fan will start when the upper setpoint of a temperature switch mounted in the air exhaust room is reached. The generator and electrical panel cooling fan can start along with either exhaust fan. The temperature switches mounted in the air exhaust room

exceeds 122°F. Similary, the electrical control panels within 52
the engine rooms are forced ventilated to assure an internal
cabinet temperature of less than 131°F.

Because the Diesel Generator Building contains no sources of potential radioactivity, there are no safety-related airflow directions that must be maintained and no required radiation monitors.

The Diesel Generator Building is a Seismic Category I structure that is designed to be safe from tornado missile and flood damage. The diesel generator room exhaust fans, the generator 52 and electrical panel fan cooling battery hood exhaust fans, electrical board room exhaust fans, and all associated ductwork, fittings, and dampers are located within the building and are 35 designed to meet Safety Class 2b and Seismic Category I requirements. These fans, their associated controls, and motor-operated dampers are connected to emergency power. The use of concrete air intake and exhaust hoods provides additional protection from the effects of missiles.

9.4.5.2.2 System Description

6 -23, -24, -24A and

The Diesel Generator Building heating and ventilating system are shown on Figures 9.4-22 ~~through~~ 9.4-25. Two diesel generator room exhaust fans, one battery hood exhaust fan, and one electrical board room exhaust fan are located in the air exhaust room at EL. 760.5 for each of the four diesel generator units. 52 These fans discharge to the outdoors. One generator and electrical panel cooling fan is located within each diesel room.

Fresh air is introduced through each air intake room and drawn to the corresponding diesel generator room. The generator and electrical panel cooling fan draws air from the room intake vicinity for distribution to the generator air intake and to the electrical panel. Following absorption of the heat load in the room the air is drawn into the air exhaust room buy the room exhaust fan(s) and is discharged through the air exhaust hood.

Each battery area is ventilated by a fan designed to exhaust approximately 1000 cfm of air from the battery area through an overhead exhaust hood. The air is drawn through ducts to the exhaust fan located in the air exhaust room. It is then discharged to the outdoors.

Each of the electrical board rooms is ventilated by a centrifugal 52
exhaust fan rated to 2850 cfm at 0.75-inch water gauge static pressure. The fan draws air into the board room through its associated electrical board room intake vent.

Other building exhaust fans provide individual ventilation for the lubricating oil storage room, fuel oil transfer room, carbon dioxide storage room, toilet room, and muffler rooms. 41

The thermostatically controlled electric unit heaters located within the diesel generator rooms, equipment access corridor, storage rooms, radiation shelter rooms, and toilet room are designed to maintain these areas at not less than 60°F when the outside ambient temperature is 15°F.

9.4.5.2.3 Safety Evaluation

A functional analysis and a failure modes and effects analysis have shown that the Diesel Generator Building ventilation system has the capabilities needed for normal operations and for accident mitigation. The functional analysis shows that:

1. Adequate ventilation is provided to achieve acceptable airflow patterns and environmental conditions for optimum equipment operation during all operational modes. See Section 9.4.5.2.1.1

2. The battery area will be constantly ventilated to prevent hydrogen buildup in the diesel generator room.

The failure modes and effects analysis, as shown in Table 9.4-4, indicates that: 28

1. During diesel generator operation, low air flows through any of the three fans within the Diesel Generator room will be detected by a flow sensor. The failure will annunciate in the MCR. 52

2. The failure of a battery hood exhaust fan will prevent forced air circulation past the batteries. However, the dampers in the exhaust ductwork will remain open and adequate airflow will pass through the system to prevent a buildup of hydrogen gas.

3. A failure of an electrical board room exhaust fan, and the resulting heat buildup in the room to above 104~F, may cause loss of the associated diesel generator. However, the remaining diesel generator will be capable of providing adequate power to safely shut down the unit.

4. Essential portions of this system will remain functional during and after a seismic event because of their design to Seismic Category I requirements. Nonessential portions of this system and other systems located close to essential components are designed to Seismic Category I(L) standards to prevent their failure from precluding operation of essential system components.

5. During flooding conditions and tornadoes, all essential components of this system will remain functional because they are located above the maximum possible flood level and are in a Seismic Category I structure that is designed to resist damage by tornado missiles.

6. Upon loss of offsite power, each diesel generator will provide emergency electrical power to its associated ventilation components. All are connected to their respective diesel generator engineered safety power supply, so operation of a diesel generator will assure power to the corresponding fans. 52

INSERT 9.4A

9.4.5.2.4 Tests and Inspections

The diesel generator building ventilating and heating systems are accessible for periodic inspection. Essential electrical components, switchovers, and starting controls are tested initially and periodically thereafter.

9.4.5.3 Auxiliary Building Safety Features Equipment Area

9.4.5.3.1 Design Bases

The auxiliary building safety features equipment ventilation system is designed to maintain acceptable environmental conditions for (1) personnel access, operation, inspection, maintenance and testing and (2) the protection of mechanical and electrical equipment and controls. The system utilizes cooling provided by the Safety Features Equipment Coolers. Air cooling units are provided for the following equipment and areas: 52

1. Residual heat removal pumps
2. Safety injection pumps
3. Containment spray pumps
4. Centrifugal charging pumps
5. Reciprocating charging pumps*
6. Unit 1 auxiliary feedwater and component cooling water pumps

INSERT 9.4A

9.4.5.2.2 ~~9.4.5.2~~ ADDITIONAL Diesel Generator Building

9.4.5.2.~~2~~.1 Design Bases

The ADDITIONAL diesel generator building ventilating system is required to BE operabl ~~operate~~ to maintain ~~plant safety in the event of a loss of offsite power due to a natural disaster or plant accident including tornado, earthquake, flood, or fire.~~ THE C-S D.G. OPERABLE WHEN THE C-S D.G IS S[illegible]TUTING FOR A[illegible] THE FOUR ORIGINAL D.G. UNITS. The diesel unit~~s~~ IS ~~are redundant and are each~~ served by a separate 100 percent redundant ventilation system. Each ventilation system maintains a proper environment for the operation of safety-related components.

THE ADDITIONAL ~~Each~~ diesel engine room ventilation subsystem consists of two room exhaust ~~fans and one generator and electrical panel cooling fan for a total of three fans.~~

One diesel generator exhaust fan ~~along with the cooling fan~~ will automatically start upon diesel startup. The second exhaust fan will start when the upper setpoint of a temperature switch mounted in the air exhaust room is reached. ~~The generator and electrical panel cooling fan can start along with either exhaust fan.~~ The temperature switches mounted in the air exhaust room monitor the temperature of the air as it leaves the diesel generator room. These switches may actuate either room exhaust fan upon detection of high diesel generator room temperature conditions or may deenergize either fan, if necessary, in order to maintain the diesel generator room exhaust temperature between 40°F and 120°F. ~~All three fans will automatically stop if the diesel generator room carbon dioxide system is activated.~~ ~~52~~

PIPE GALLERY, FIRE PROTECTION ROOM, CORRIDOR, TRANSFER ROOM

JANITOR CLOSET 6.9KV BOARD ROOM, 480V AUXILIARY BOARD ROOM

The ~~toilet room~~ is ventilated at all times. The ~~electrical board rooms, battery hoods, lube oil storage room,~~ and oil transfer room are ventilated at all times ~~except when their respective carbon dioxide systems are activated~~. The muffler room ~~are~~ IS ventilated as required to remove heat during warm weather. Muffler room exhaust fan ~~are~~ IS manually operated from hand switches located on the electrical board that serves the particular fan, or start along with the diesel when in the auto mode. ~~39~~ FUEL PUMP ~~52~~

Three types of dampers are used in the diesel generator ventilation system. Fire dampers, provided in each air supply and exhaust openings to the ~~diesel generator room, electrical board room, lube oil storage room,~~ 6.9KV BOARD ROOM, 480V AUXILIARY BOARD ROOM and FUEL oil transfer PUMP room, will automatically close upon detection of a fire. THE Motor-operated damper located at the air intake to ~~each~~ THE ADDITIONAL diesel generator room IS ~~are~~ automatically opened whenever either of the exhaust fans start. All fans except for the 480V AUXILIARY BOARD ROOM EXHAUST FAN AND FUEL OIL TRANSFER EXHAUST FAN are equipped with motor operated shutoff dampers which close when their associated fan is not operating. ~~Similary, all relief vents are provided with motor operated shutoff dampers except the electrical board room intake vents which are provided with fire dampers instead.~~ ~~52~~

~~A backdraft damper is installed in the duct between the air intake room 1A-A and the carbon dioxide storage room in order to prevent carbon dioxide backflow into the diesel generator air intake room in the event of a carbon dioxide system rupture.~~

THE ADDITIONAL ~~Each~~ diesel generator unit room is ~~separately~~ ventilated ~~in order~~ to limit average room temperatures to a design maximum of 120°F when outdoor air entering the room is 97°F and the diesel generator is in operation. ~~Electrical board rooms~~ THE 480V BOARD ROOM AND 6.9KV BOARD ROOM are ~~individually~~ ventilated in order to limit room temperatures to a design maximum of 104°F when the entering outside air temperature is 97°F. Remaining areas of the ADDITIONAL Diesel Generator Building are ventilated using the method of room volume changes. Personnel comfort conditions are maintained as required during low outside temperature by means of thermostatically controlled electric unit heaters. ~~Battery areas are ventilated at all times for hydrogen removal~~. ~~52~~

~~The generator for each engine room is supplied with outside air to ensure that the average generator air intake temperature never~~ ~~52~~

~~exceeds 122°F. Similary, the electrical control panels within the engine rooms are forced ventilated to assure an internal cabinet temperature of less than 131°F.~~

Because the Additional Diesel Generator Building contains no sources of potential radioactivity, there are no safety-related airflow directions that must be maintained and no required radiation monitors.

The Additional Diesel Generator Building is a Seismic Category I structure that is designed to be safe from tornado missile and flood damage. The additional diesel generator room exhaust fans, the 480V auxiliary board room exhaust fan, transformer and 6.9KV board room exhaust fan and fuel oil transfer room ~~electrical board room~~ exhaust fan~~s~~, and all associated ductwork, fittings, and dampers are located within the building and are designed to meet Safety Class 2b and Seismic Category I requirements. These fans, their associated controls, and motor-operated dampers are connected to emergency power. The use of concrete air intake and exhaust hoods provides additional protection from the effects of missiles.

9.4.5.2.2.2 ~~9.4.5.3.2.2~~ System Description

The Additional Diesel Generator Building heating and ventilating system are shown on Figures ~~9.4-23 through 9.4-25~~ 9.4-22A through 9.4-22C. Two diesel generator room exhaust fans, one fuel oil transfer room exhaust fan, one transformer and 6.9KV room exhaust fan and one 480V auxiliary board room exhaust fan are located in the air exhaust room at EL. 760.5 for ~~each of~~ the ~~four~~ additional diesel generator units. These fans discharge to the outdoors. ~~One generator and electrical panel cooling fan is located within each diesel room.~~

Fresh air is introduced through the ~~each~~ air intake room and drawn into ~~to~~ the corresponding diesel generator room. ~~The generator and electrical panel cooling fan draws air from the room intake vicinity for distribution to the generator air intake and to the electrical panel~~. Following absorption of the heat load in the room the air is drawn into the air exhaust room buy the room exhaust fan(s) and is discharged through the air exhaust hood.

~~Each battery area is ventilated by a fan designed to exhaust approximately 1000 cfm of air from the battery area through an overhead exhaust hood. The air is drawn through ducts to the exhaust fan located in the air exhaust room. It is then discharged to the outdoors.~~

~~Each of the electrical board rooms is ventilated by a centrifugal exhaust fan rated to 3850 cfm at 0.75 inch water gauge static pressure. The fan draws air into the board room through its associated electrical board room intake vent.~~

The 480 V auxiliary board room is ventilated by a centrifugal fan which draws air from the outside through the roof mounted air intake. The transformer and 6.9 KV board rooms are ventilated by a centrifugal fan which draws air from the air intake room.

Other building exhaust fans provide individual ventilation for the ~~lubricating oil storage room~~, Janitor closet, fuel oil transfer Pump room, ~~carbon dioxide storage room, toilet room~~, and muffler rooms.

The thermostatically controlled electric unit heaters located within the diesel generator room~~s~~, ~~equipment access~~ corridor, fire protect. ~~storage rooms~~, ~~radiation shelter~~ transformer room~~s~~, 480 V auxiliary board room, 6.9 KV board room, pipe gallery, and ~~toilet~~ room are designed to maintain these areas at not less than 60°F when the outside ambient temperature is 15°F.

[illegible]mostats in the diesel generator air exhaust room ar[illegible]signed to automatically stop all operating diesel gene[illegible]or room fans upon a drop in room exhaust air temperature to below 40°F, and to automatically start the exhaust fans upon room temperature rise to 80°F. The thermostats will also start the standby exhaust fan, during diesel generator operation, when the room exhaust air temperature exceeds 80°F.

9.4.5.2.2.3 ~~9.4.5.2.3~~ Safety Evaluation

A functional analysis and a failure modes and effects analysis have shown that the Additional Diesel Generator Building ventilation system has the capabilities needed for normal operations and for accident mitigation. The functional analysis shows that:

1. Adequate ventilation is provided to achieve acceptable airflow patterns and environmental conditions for optimum equipment operation during all operational modes. See Section 9.4.5.2.~~1~~.2.

~~2. The battery area will be constantly ventilated to prevent hydrogen buildup in the diesel generator room.~~

The failure modes and effects analysis, as shown in Table 9.4-4A, indicates that:

1. During diesel generator operation, low air flows through any of the ~~these~~ fans within the Diesel Generator room will be detected by a flow sensor. The failure will annunciate in the MCR.

~~3. The failure of a battery hood exhaust fan will prevent forced air circulation past the batteries. However, the dampers in the exhaust ductwork will remain open and adequate airflow will pass through the system to prevent a buildup of hydrogen gas.~~

2. ~~3~~. A failure of an electrical board room exhaust fan, and the resulting heat buildup in the room to above 104~F, may cause loss of the ~~associated~~ diesel generator. However, the remaining diesel generator will be capable of providing adequate power to safely shut down the unit.

3. ~~4~~. Essential portions of this system will remain functional during and after a seismic event because of their design to Seismic Category I requirements. Nonessential portions of this system and other systems located close to essential components are designed to Seismic Category I(L) standards to prevent their failure from precluding operation of essential system components.

4 ~~8~~. During flooding conditions and tornadoes, all essential components of this system will remain functional because they are located above the maximum possible flood level and are in a Seismic Category I structure that is designed to resist damage by tornado missiles.

5 ~~8~~. ~~Upon loss of offsite power, each diesel~~ WHEN THE ADDITIONAL DIESEL generator IS SUBSTITUTED FOR ANY ONE OF THE NORMALLY ALIGNED UNITS IT will provide emergency electrical power to its associated ventilation components. All are connected to the~~ir~~ ADDITIONAL ~~respective~~ diesel generator engineered safety power supply, so operation of ~~a~~ THE ADDITIONAL diesel generator will assure power to the corresponding fans.

9.4.5.2.~~X~~ 2.4 Tests and Inspections

The ADDITIONAL Diesel Generator Building ventilating and heating systems are accessible for periodic inspection. Essential electrical components, switchovers, and starting controls are tested initially and periodically thereafter.

Since the additional diesel generator is intended as a replacement for any one of the other four diesel generators, all five diesel generators will not be operating at the same time

accordance with routine plant procedures. 52

9.5.4 Diesel Generator Fuel Oil Storage and Transfer System

9.5.4.1 Design Bases

any four of the five — which could be

The Diesel Generator Fuel Oil System is designed to provide independent storage and transfer capacity to supply No. 2 Fuel Oil to ~~all four~~ any four of the five diesel generator units which could be operating at full load for an extended period of time.

Each of the skidmounted day tanks (one per diesel engine) on each diesel generator unit has a storage capacity of 550 gallons. The portion of the Diesel Generator Fuel Oil System necessary to supply fuel for a minimum of seven days is located within the diesel generator building or the additional diesel generator building. The buildings ~~is~~ are designed to Seismic Category I and ~~is~~ are designed to withstand the affects of tornados, credible missiles, floods, rain, snow, or ice, as defined in Chapter 3, Sections 3.3, 3.4, and 3.5. 52

The design code requirements for the system are as follows:

1. Diesel generator building fuel oil storage tanks - Code for Unfired Pressure Vessels, ASME Section VIII, Division I.

2. Piping from fuel oil storage tanks to interface of diesel generator units - Boiler and Pressure Vessel Code, ASME Section III, Class III. 41

3. Remaining piping, valves, pumps, and associated equipment - Power Piping Code, ANSI B31.1-1973.

The diesel fuel oil storage tanks are designed for embedment within the diesel generator building and additional diesel generator foundations. The fuel oil day tanks are skid-mounted on the diesel generator units, and have an ambient temperature range of ~~60~~ 40° to ~~120~~ 110°F. ~~The diesel oil transfer pump is designed to handle fuel oil at a temperature of 0 to 100°F.~~ delete

The Diesel Fuel Oil System for the diesel generator units is designed to meet the single failure criterion. That portion of the system from the embedded storage tanks to the diesel generator units is designed to meet Seismic Category I requirements. The remainder of the system within the Diesel Generator Building is designed to Seismic Category I(L) requirements. 49

9.5.4.2 System Description

The flow diagram of the Diesel Generator Fuel Oil System is shown in Figure 9.5-20 and 9.5-20a. The control and logic diagrams are shown in Figures 9.5-21 and 9.5-22, respectively.

or additional diesel generator building

The Diesel Generator Fuel Oil System consists of ~~four~~ five embedded storage tank assemblies, one for each diesel generator unit, with their associated day tanks, pumps, valves, and piping. The tanks themselves are embedded in the Diesel Generator Building or additional diesel generator building substructure and have a capacity of 68,000 gallons of fuel for each diesel generator unit. 49

Level switches are provided on the ~~diesel generator building~~ storage tank assemblies to provide the following functions:

1. Provide local fuel level indication.

2. Annunciate an alarm in the Main Control Room when the fuel level drops below a seven-day supply.

3. Annunciate an alarm in the Main Control Room on high level above the pump shut-off setting.

4. Provide an interlock with the 200 gpm transfer pumps at the yard storage tanks and in the diesel building fuel oil transfer room, to shut off the pumps automatically on high level. This interlock feature is not employed when using the Additional Diesel Generator Building (ADGB) fuel oil transfer pump or in transferring fuel oil to the ADGB fuel oil tanks. 49

A truck fill-connection, condensate sump suction connection, and inspection-dipstick gauge manholes are provided for each embedded storage tank assembly. The vents to the atmosphere on all tank assemblies are provided with double fire screens to prevent an outside spark from entering the assemblies and igniting the gases within. All tank connections and vents are above maximum flood elevation. That portion of the seven-day fuel oil tank vent above the roof level is encased in reinforced concrete for missile protection. 52

Two skid-mounted, electric motor driven, 15 gpm fuel oil transfer pumps are provided for each generating unit to transfer fuel from the embedded storage tank assembly~~ies~~ to the two skid-mounted day tanks ~~per~~ of each generating unit. Each of these pumps ~~is capable of supplying~~ supplies fuel to both day tanks.

Two sets of level switches are provided for each day tank and associated transfer pumps. The level switches are arranged so that one pump will be the primary pump and the other a supplementary pump. The supplementary pump is provided so that in the event of a failure of the primary pump, the supplementary pump will start. In addition, these level switches provide both local and backup remote alarms to indicate high and low fuel oil level in the day tanks. 49 52

From each day tank, fuel is supplied to the diesel injectors by a diesel engine driven pump. An electric motor-driven fuel pump is provided as a backup for the engine driven fuel pump. Separate suction and discharge lines serve each pump. Each line has a

A 200 gpm transfer pump located adjacent to the yard fuel oil storage tanks provide~~s~~ the following functions:

1. Transfer fuel oil from a tank truck to either of two yard fuel oil storage tanks.

2. Transfer fuel oil from either yard fuel oil storage tank to the other.

3. Transfer fuel oil from either yard fuel oil tank to any one of the five ~~four diesel generator building~~ embedded fuel oil storage tank assemblies.

4. Reject fuel oil from either yard fuel oil tank through a reject connection in the yard.

9.5.4.3 Safety Evaluation

With 60,000 gallons of diesel fuel in each fuel tank assembly, and each assembly embedded in the concrete substructure of a Seismic Category I building and separated by 18 inches of concrete, the diesel generator units will be assured of having at least 7 days fuel supply for any of the conditions discussed in Section 9.5.4.1. The diesel generator fuel oil tank assemblies, piping, and pumps are so arranged that malfunction or failure of either an active or passive component associated with the source of supply for any one diesel generator unit will not impair the ability of the other sources to supply fuel oil to the other units. 49

Seismically qualified 200 gpm fuel oil transfer pumps are also located in the diesel generator building (DGB) and additional diesel generator building (ADGB).

The DGB fuel oil transfer pump will allow fuel oil to be transferred from any one of the embedded fuel oil storage tanks in the DGB to any other embedded fuel oil storage tanks in the DGB, ADGB, or either yard storage tank.

The ADGB fuel oil transfer pump can transfer fuel oil from the embedded fuel oil storage tanks in the ADGB to any one of the DGB embedded storage tanks or to either yard storage tank.

Each diesel generator is aligned so as to be able to supply power to its own auxiliaries so that a single failure will not result

In the Additional Diesel Generator Building, an Aqueous Film Forming Foam (AFFF) fire suppression system is used in place of the carbon dioxide system found in the diesel generator building.

in loss of more than one diesel generator unit. The system thus meets the requirements of the single failure criterion.

As discussed in Section 9.5.4.2, all connections and vents to the atmosphere are above flood elevation. The vents are flame-proofed. In addition, automatic carbon dioxide fire protection is provided in the diesel building fuel oil transfer pump room and the four rooms housing the diesel generator units.

~~The interlock feature noted in Section 9.5.4.2, automatically controls the operation of the yard and diesel generator transfer pumps to prevent accidental overfilling of and spillage from the Diesel Building storage tank assemblies.~~ Delete

A 0.125 inch corrosion allowance has been provided in the design wall thickness for the diesel generator building embedded fuel oil storage tanks. The interiors of the tanks were coated with Humble Oil Company's Rustband No. 357 for added corrosion protection. The fuel oil piping and fittings within the diesel generator building have more than ample corrosion allowance, having been designed per the codes noted in Section 9.5.4.1, and will operate at a pressure considerably below the maximum allowable for the size and schedule pipe fittings used.

It is expected that additional fuel oil beyond that stored on-site can be procured and delivered to the plant site within a reasonable period of time because of the following:

1. The plant site is served by a railroad spur owned by TVA.

   The yard transfer pump is provided for transferring fuel oil from a tank car to either of the two fuel oil tanks in the yard, or directly to the diesel fuel oil storage tank assemblies.

2. The possibility that the truck-fill connections located outside the Diesel Generator Building, one for each of the five ~~four~~ diesel oil storage tank assemblies, might not be accessible by truck under any weather conditions is very remote, because Tennessee State Highway 68 provides yearround transportation through the site area. In addition, two highways connecting Knoxville and Chattanooga, State Highways 29 (U.S. 27) and 58 pass within ten miles of the plant site.

3. If rail or road transportation is unavailable, barge or tanker delivery can be accepted at the dock area on the west bank of the Tennessee River near the plant site. 26

A failure modes and effects analysis for the Diesel Generator Fuel Oil Storage and Transfer Subsystem is presented in Table 9.5-2.

~~A failure modes and effects analysis for the Diesel Generator Intake and Exhaust Subsystem is presented in Table 9.4-4.~~ 32

9.5.4.4 Tests and Inspections

and Additional Diesel Generator Building

The engine-mounted, motor and engine-driven fuel oil transfer pumps and day tanks were functionally tested in the vendor's shop in accordance with the manufacturer's standards to verify the performance of the diesel generator units and accessories. The fuel oil transfer pumps in the yard, ~~and~~ Diesel Generator Building, were tested in the manufacturer's factory to verify their performance. The embedded fuel oil storage tanks were tested with compressed air to 20 psig prior to shipment to the plant site.

The entire Diesel Fuel Oil System was flushed with oil and then functionally tested at the plant site in accordance with TVA Preoperational Test TVA-14A and 74A. The Diesel Fuel Oil System will be periodically tested to satisfy the Technical Specification 3/4.8, surveillance requirement 4.8.1.1.2. 55

9.5.5 Diesel Generator Cooling Water System

9.5.5.1 Design Bases

9.5.5.2 System Description

A closed-loop circulating water cooling system is furnished for each engine of the four tandem diesel generator units and the one unit in the ADGB housed within the Diesel Generator Buildings. These Buildings ~~is~~ are designed to Seismic Category 1 requirements, and ~~is~~ are designed to withstand the effects of tornadoes, credible missiles, hurricanes, floods, rain, snow, or ice as defined in Chapter 3 Sections 3.3, 3.4, and 3.5). Each cooling system includes 2 pumps, heat exchanger expansion tank, and all accessories required for a cooling loop. (See Figure 9.5-23). To preclude long term corrosion or organic fouling the engine cooling water system requires de-ionized water with a corrosion inhibitor. The water chemistry is maintained in conformance with the engine manufacturer's recommendations, General Motors Corporation MI 1748. The closed-loop engine cooling water is circulated through the shell side of each skid-mounted heat exchanger by two diesel-engine shaft-driven pumps. Jacket water immersion heaters are provided for each engine to maintain the jacket water within the vendor recommended temperature range in order to reduce thermal stresses and assure the fast starting and load accepting capability of the diesel generator units in performing their required safety function. 55 28 52 42 52

The immersion heater is energized when the water at the temperature switch falls to 125°F ~~(± 3 percent)~~ and goes off at 155°F ~~(± 3 percent)~~. A jacket water temperature low alarm annunciates when the water at the temperature switch falls to 100°F ~~(± 3 percent)~~. 53

Jacket water flows through the lubrication oil cooler by thermosyphon action when the diesel generators are idle. An electric motor driven lubrication oil circulation pump is also provided for each engine to circulate the lubrication oil through the lubrication oil cooler, which is warmed by the engine jacket water, and return the oil to the engine sump. The jacket water immersion heaters are controlled by thermostats, and the lubrication oil circulation pumps run continuously when the engine is not running.

Each diesel generator unit is provided with two closed engine cooling water loops (one for each engine), for which the heat sink is provided by the Essential Raw Cooling Water (ERCW) System. (refer to Section 9.2.1) The ERCW flows through the tube side of the skid-mounted heat exchangers. 55

9.5.5.3 Safety Evaluation

The cooling water is supplied to the heat exchangers of each diesel generator unit through redundant headers of the ERCW System. The system isolation valves are so arranged as to provide the capability to isolate either cooling source in the event of a component malfunction or excessive leakage from the system. Refer to Figures 9.2-1 through 9.2-4. Therefore a malfunction (single failure of a component) or loss of one cooling water source will not jeopardize the function of a diesel generator unit. Both the air-start piping and ~~carbon dioxide~~ fire protection piping located in the vicinity of the Diesel Generator Cooling Water System are designed to Seismic Category I(L) to ensure that no seismic event will degrade the functional capability of the Diesel Generator Cooling Water System.

9.5.5.4 Tests and Inspections

The ERCW System within the Diesel Generator Building was hydrostatically tested to 240 psig and functionally tested on the plant site in accordance with TVA Preoperational Test TVA-18, -14E, and 73C. All system components are accessible for periodic inspections during operation. The diesel Generator Coolant Water System is periodically tested to satisfy Technical Specification 3/4.8.

~~Manufacturer's recommendations are that the diesel generators not~~ be run for extended periods of time at less than 50% of continuous rated load. For all situations, TVA has loads 28 continuously available to the operator that exceed 50% of the continuous rated load.

Delete, This is in Section 8.3 (pg 8.3-11)

The manufacturer has indicated that the diesel engines have been tested for no-load operation for four hours.

After four hours of operation at less than 30-percent load, the diesel generator is run at a minimum of 50-percent load for at 45 least 30 minutes.

The diesel generators will automatically start on an accident signal and if off-site power remains available, the diesel 28 generators will be put back in standby condition before the four hour period is ended.

After an accident situation when the diesel generator has run for an extended period of time at low or no loads, the load is gradually increased until the exhaust smoke is approximately 45 twice as dense as normal. The increasing load is then stopped until the smoke clears. This procedure is repeated until full ~~load can be carried with a clear exhaust.~~

All skid-mounted Diesel Generator Cooling Water System components 28 are inspected and services as specified in the scheduled maintenance program for the Watts Bar Nuclear Plant diesel generator units.

9.5.6 Diesel Generator Starting System

9.5.6.1 Design Bases

Each diesel engine associated with the ~~four~~ five tandem diesel generator units is equipped with an independent pneumatic starting system. See Figure 9.5-24. The Diesel Starting Air System components are housed with their respective diesel generator units within the diesel generator rooms in the Diesel Generator Building, and ADGB which ~~is~~ are a Seismic Category I structure designed to withstand the effects of tornadoes, credible missiles, floods, rain, snow, or ice, as defined in Chapter 3, Sections 3.3, 3.4, and 3.5.

9.5.6.2 System Description

Each diesel engine has two pairs of air starting motor units (hence, there are four pairs per diesel generator unit). ~~and any two pairs on a unit are capable of starting the diesel generator unit.~~ A set of two skid-mounted air accumulators is provided for each diesel engine; four accumulators per diesel generator unit.

minimum of two pairs of air start motors are needed to start the diesel generator unit.

The accumulators are 30 inches in diameter and 104 inches long, and are designed in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII. Each set of accumulators is sized for a compressed air storage capacity sufficient to ~~crank~~ Start the diesel generator unit five times without recharging. One accumulator of each set serves as a standby for the other (primary) accumulatory of that set. Each set of accumulators is equipped with pressure gauges, drains, shutoff valves, safety relief valves, check valves, instrumentation, and controls.

Two 480-volt a.c. motor-driven compressors supply compressed air to each of the two sets of accumulators for each diesel generator unit. Each compressor is sized to recharge any one accumulator of a set from 150 psig to 250 psig within 30 minutes. Controls for the compressors have been designed for automatic start-stop operation (start at a falling pressure of 200 psig, stop at a rising pressure of 250 psig). Manual test-start selector switches are also provided for each compressor. ~~Transmitters~~ Pressure Switches are provided on each Air Starting System for actuating low air pressure alarms both locally and in the Main Control Room (see Figure 9.5-25.

The ~~two~~ its supply headers from ~~the~~ each air compressor to the isolation check valve on ~~each~~ skid-mounted accumulator are designed to Seismic Category I(L) requirements. To prevent moisture and rust accumulation in the air starting system, a fully automatic heatless air dryer has been installed between the air compressor and the accumulators. The air dryer unit contains dual desiccant drying chambers which are alternately cycled through drying and regeneration cycles, a forced air aftercooler, and associated cycle and fan controls. One chamber of the desiccant dryers is on stream at all times. Moisture traps are also located downstream of the dryers to collect any residual moisture. The two air storage systems for each diesel generator unit provide redundancy so that a single failure will not jeopardize the design starting capacity of the system.

9.5.6.3 Safety Evaluation

All equipment necessary to start the diesels upon receipt of a start signal is Seismic Category I.

The diesel air start system is classified as quality group C. Section B of Regulatory Guide 1.26 discusses quality groups A through D and generally the types of equipment falling in each group. Section B also discusses systems and components not covered by groups A-D. Examples of these non-covered items are provided in Regulatory Guide 1.26 and include instrument and service air systems, auxiliary support systems and diesel engines. Part NA-1130, Section III of the ASME code states that drive system and other accessories are not part of the code. Regulatory Guide 1.26 states that non-covered items should be designed, fabricated, erected and tested to quality standards commensurate with the safety functions performed. As a quality 24 group C system, it is considered to meet quality standards commensurate with the safety function performed. 24

The piping for the air start system is designed to minimize rust accumulation in the system. Moisture is accumulated at the low points in the system and removed by administrative blowdown procedures. A strainer is also provided in the air start piping system upstream of the air start motors which prevents carry over of oil or rust, etc., to the motors. 28 An oil mist type lubricator located in the air start system piping downstream of the line strainer and before the air start motors, provides lubrication for the motors. The typical arrangement for each engine is a strainer and lubricator for each pair of air start motors. The diesel starting air system is shown in Figure 9.5-24 and 24a

9.5.6.4 *Tests and Inspections*

The entire Diesel Generator Starting System will be functionally tested in accordance with TVA Preoperational Test TVA-14B and TVA-74B. The system will be periodically tested to verify its ability to function as part of the diesel generator unit to satisfy the 24 Technical Specification 3/4.8 surveillance requirement 4.8.1.1.2. Under normal standby conditions, the Diesel Generator Starting System is maintained and inspected at intervals as prescribed in the plant maintenance instructions for the diesel generator units. 52

9.5.7 Diesel Engine Lubrication System

9.5.7.1 *Design Bases*

The Diesel Engine Lubrication System for each diesel engine shown in Figure 9.5-26, is a combination of three subsystems: the main lubricating subsystem, the piston cooling subsystem, and the scavenging oil subsystem.

The main lubricating subsystem supplies oil under pressure to the various moving parts of the diesel engine. 52 The piston cooling subsystem supplies oil for piston cooling and lubrication of the piston pin bearing surfaces. The scavenging oil subsystem supplies the other systems with cooled and filtered oil. Oil is drawn from the engine sump by the scavenging pump through a strainer in the strainer housing located on the front side of the engine. From the strainer the oil is pumped through oil filters and a cooler. The filters are located on the accessory racks of the engines. The oil is cooled in the lubricating oil cooler (as 52 shown in Figure 9.5-27) by the closed circuit cooling water system in order to maintain proper oil temperature during engine operation.

The required quality of oil is maintained by scheduled maintenance of strainers, separators, and filters and by oil changes in accordance with the engine manufacturer's recommendation. 28

A crankcase pressure detector assembly is provided to cause the crankcase

engine to shut down in case the normal negative crankcase pressure changes to a positive pressure. This is accomplished by relieving the oil pressure to the engine governor. The crankcase pressure detector shutdown device is operative only during diesel generator testing; see FSAR Paragraph 8.3.1.1 under the heading, 'Standby Diesel Generator Operation.' 28

An overspeed mechanism is provided to shut down the engine by stopping the injection of fuel into the cylinders should the engine speed become excessive.

9.5.7.2 System Description

When the diesel generator units are not operating but are in the standby condition, the auxiliary oil system is used to circulate the oil through the engine cooler where it is warmed by the cooling water. (Refer to Section 9.5.5, Diesel Generator Cooling Water System.) Thus, the engines are kept in constant readiness for an immediate start. 52

The lubricating oil and piston cooling oil pumps are of the positive displacement helical gear type, mounted externally on the front of the engine for accessibility. They are gear driven from the diesel engine. All lubricating oil pumps are mounted on the diesel engines, skid, or DGB (or ADGB) floor. 52

Each of Five the engines in the tandem generator ~~sets~~ is provided with its own lubricating oil system, which is ~~an~~ integral part of each of the ~~four~~ diesel generator units (see Figure 9.5-27) housed within the Diesel Generator Building or the additional generator building. The original four diesel generators have been modified to add engine manufacturer's recommended improvements to the lube oil system (MI 964). This modification includes the addition of an a.c. motor driven lube oil pump and a d.c. motor driven auxiliary lube oil pump. The a.c. lube oil pumps circulate lubication oil constantly to provide adequate lubrication of the turbocharger bearings prior to engine start, removes residual heat from the turbocharger bearings after engine shutdown, and circulates warm oil through the oil system to keep the engine in a constant state of readiness for an immediate start. The Diesel Generator Building and additional diesel generator building ~~is~~ are designed to Seismic Category I requirements, and ~~is~~ are designed to withstand the effects of tornados, credible missiles, hurricanes, floods, rain, snow, or ice as defined in Chapter 3, Sections 3.3, 3.4, and 3.5. 52

The additional diesel generator unit (ADGU) was purchased with this modification already included

The diesel lubricating oil instrumentation alarms are activated to signal on any of the following conditions:

1. Low standby lubricating oil pressure
2. Low engine lubricating oil pressure
3. Low crankcase engine oil level
4. Low engine oil pressure at idle

The d.c. Lube Oil Pump serves as a backup to the ac pump and removes heat from the turboCharger bearings should the engine be shut down without ac power available.

High crankcase pressure

(or additional generator building)

Local engine oil pressure and temperature gauges are provided. The diesel lubricating oil instrumentation alarms visually and audibly in both the Diesel Generator Building and Main Control Room. Each diesel generator is arranged so as to be able to supply power to its own auxiliaries such that a single failure will not result in loss of more than one diesel generator unit.

9.5.7.3 Safety Evaluation

Each engine crankcase sump contains ~~400~~ 330 gallons of lubricating oil, ample for at least seven days of diesel generator unit full load operation without requiring replenishment. The established oil consumption rate is 0.83 gallons per hour. An additional standby oil reserve of approximately 935 gallons is stored within the plant's power stores to replenish the engines for longer periods of operation and to "top off" the engines after their periodic test operations as specified in the Technical Specifications. 55

NEW ¶ 9.5.7.4 TEST AND INSPECTIONS

The diesel generator lubricating oil system components are inspected and serviced as specified in the "Scheduled Maintenance Program for the Watts Bar Diesel Generator Units." The inspection and service of the lubricating oil systems includes visual checking for, and the correction of, oil leakage. This program sets overall standards and testing instructions to quality all lubricating oil for use in the diesel generator engines. 28

9.5.8 Diesel Generator Combustion Air Intake and Exhaust System

9.5.8.1 Design Bases

~~The tandem~~ Each diesel engine associated with each of the ~~four~~ five tandum diesel generator units ~~are~~ is equipped with an independent Combustion Air Intake and Exhaust Subsystem. The four original subsystems for the plant are housed in physically separated rooms within the Diesel Generator Building. The Buildings ~~is~~ are designed to Seismic Category I requirements, and ~~is~~ are designed to withstand the effects of tornadoes, credible missiles, hurricanes, floods, rain, snow, and ice as defined in Sections 3.3, 3.4, and 3.5. The Combustion Air Intake and Exhaust Subsystem piping, filters, and silencers are so arranged in the individual rooms for each diesel generator unit that a malfunction or failure of any system component associated with any single unit will not impair the operation of the other units. The sub-system thus meets the requirements of the single failure criterion. 35

The additional diesel generator is located in its own building which is physically separated from the Diesel Generator Building housing the other four diesels. The combustion air intake and exhaust systems are arranged in a manner similar to the arrangement for each of the four diesels' air intake and exhaust systems.

9.5.8.2 System Description

The general arrangement of the Diesel Generator Combustion Air Intake and Exhaust System is shown in Figure 8.3-1. The flow diagrams are shown in Figures 9.5-29 and 9.5-30. Each Diesel Generator Combustion Intake and Exhaust Subsystem includes an air 41

(or additional generator building)

High crankcase pressure

Local engine oil pressure and temperature gauges are provided. The diesel lubricating oil instrumentation alarms visually and audibly in both the Diesel Generator Building and Main Control Room. Each diesel generator is arranged so as to be able to supply power to its own auxiliaries such that a single failure will not result in loss of more than one diesel generator unit.

9.5.7.3 Safety Evaluation

Each engine crankcase sump contains ~~400~~ 330 gallons of lubricating oil, ample for at least seven days of diesel generator unit full load operation without requiring replenishment. The established oil consumption rate is 0.83 gallons per hour. An additional standby oil reserve of approximately 935 gallons is stored within the plant's power stores to replenish the engines for longer periods of operation and to "top off" the engines after their periodic test operations as specified in the Technical Specifications. 55

NEW ¶ 9.5.7.4 TESTS AND INSPECTIONS

The diesel generator lubricating oil system components are inspected and serviced as specified in the "Scheduled Maintenance Program for the Watts Bar Diesel Generator Units." The inspection and service of the lubricating oil systems includes visual checking for, and the correction of, oil leakage. This program sets overall standards and testing instructions to quality all lubricating oil for use in the diesel generator engines. 28

9.5.8 Diesel Generator Combustion Air Intake and Exhaust System

9.5.8.1 Design Bases

~~The tandem~~ Each diesel engine associated with each of the ~~four~~ five tandum diesel generator units ~~are~~ is equipped with an independent Combustion Air Intake and Exhaust Subsystem. The four original subsystems for the plant are housed in physically separated rooms within the Diesel Generator Building. The Buildings ~~is~~ are designed to Seismic Category I requirements, and ~~is~~ are designed to withstand the effects of tornadoes, credible missiles, hurricanes, floods, rain, snow, and ice as defined in Sections 3.3, 3.4, and 3.5. The Combustion Air Intake and Exhaust Subsystem piping, filters, and silencers are so arranged in the individual rooms for each diesel generator unit that a malfunction or failure of any system component associated with any single unit will not impair the operation of the other units. The sub-system thus meets the requirements of the single failure criterion. 35

9.5.8.2 System Description

The general arrangement of the Diesel Generator Combustion Air Intake and Exhaust System is shown in Figure 8.3-1. The flow diagrams are shown in Figures 9.5-29 and 9.5-30. Each Diesel Generator Combustion Intake and Exhaust Subsystem includes an air 41

The additional diesel generator is located in its own building which is physically separated from the Diesel Generator Building housing the other four diesels. The combustion air intake and exhaust systems are arranged in a manner similar to the arrangement for each of the four diesels air intake and exhaust systems.

(or additional diesel generator building)

intake filter, air intake silencers, and piping of the air intake subsystem from the air intake to its connection to the engine; and an exhaust silencer and piping of the exhaust subsystem from its connec-tion to the engine to a point just above the Diesel Generator Building roof level where the exhaust exits to the atmosphere. As shown in Figure 8.3-1, the major components of the Diesel Generator Combustion Air and Exhaust System are housed within the Diesel Generator Building which provides protection from missiles, snow, and ice. That portion of the exhaust sub-systems exposed above the roof level is short and below the parapet level to reduce the vulnerability to tornado missiles. Drain holes are provided at appropriate points to expel any rainfall that enters the exhaust piping. 37

9.5.8.3 <u>Safety Evaluation</u>

The Diesel Generator Combustion Air Intake and Exhaust System is designed to function before, during, and after a SSE, to ensure that a seismic event will not degrade the Combustion Air Intake and Exhaust System to the point that the function of a diesel generator unit is jeopardized.

An analysis of diesel generator exhaust recirculation utilizing a model developed by Halitsky 1 for transverse jet plumes, established that the exhaust plume will be carried well above the level of the air intakes and thus will not degrade the intake air. The diesel generator units can withstand a concentration of 20 percent carbon dioxide (by volume) in the air intake stream and continue to function at rated, full-load power. The redundancy and separation of the four intake and exhaust subsystems are discussed in Section 9.5.8.1. The protection against missiles, snow, rainfall, and ice are discussed in Section 9.5.8.2.

~~A failure modes and effects analysis for the Diesel Generator Fuel Oil Storage and Transfer Subsystem is presented in Table 9.5-3~~. A failure modes and effects analysis for the Diesel Generator Ventialation System and the Intake and Exhaust Subsystem is presented in Table 9.4-4. 28 39

9.5.8.4 <u>Tests and Inspection</u>

After installation the entire Diesel Generator Combustion Air Intake and Exhaust System will be functionally tested on the plant site in accordance with TVA Preoperational Test TVA-14E and -74E.

Each Diesel Generator Combustion Air Intake and Exhaust Subsystem is periodically tested to verify its ability to function as part of the diesel generator unit in accordance with Technical Specification 3/4.8, surveillance requirement 4.8.1.1.2.

Under normal standby conditions, the Diesel Generator Combustion Air Intake ~~and Exhaust~~ Subsystem is inspected at intervals as

TABLE 3.2-1

CATEGORY I STRUCTURES

1. Reactor Building (Shield Building, Steel Containment Vessel, and Interior Concrete)

2. Auxiliary - Control Building

   a. Auxiliary building portion
   b. Additional equipment building portion
   c. Control bay portion
   d. Waste packaging area

3. Condensate Demineralizer Waste Evaporator Building

4. Class 1E Electrical Systems, Manholes, Hardholes, Conduit and Conduit Banks

5. Diesel Generator Building

6. ERCW Pipe Tunnels and RWST Foundations

7. ERCW Structures

8. North Steam Valve Room

9. Intake Pumping Station and Retaining Walls

10. Additional Diesel Generator Building

11-1-80

NEW TABLE

TABLE 3.5-17

TORNADO MISSILE SPECTRUM D

For additional Diesel Generator Building and and additional Category I structures after July 1979.

Missile Description	Weight (lb)	Cross Section	Length (ft)	Horizontal Velocity (ft/sec)
Wooden Plank	115	4" x 12"	12	272
Steel Rod	9	1" dia	3	167
6" Schedule 40 Pipe	287	6" dia	15	171
12" Schedule 40 Pipe	750	12" dia	15	154
Utility Pole	1124	13-1/2" dia	35	180
Automobile	4000	6.5' x 4.3'	16.5	194

Note: Vertical velocities of 70 percent of the postulated horizontal velocities are acceptable except for the 1 inch steel rod which shall have a vertical velocity equal to its horizontal velocity (167 fps). These missiles are capable of striking in any horizontal or downward direction and at all elevations.

TABLE 3.5-18

FOR THE ADDITIONAL DIESEL GENERATOR BUILDING AND ADDITIONAL CATAGORY I STRUCTURES ADDED AFTER JULY 1979

Minimum Wall and Roof Thickness Requirements
To Resist the Effects of Tornado Missile Impact

Tornado Intensity Region	28-Day Concrete Strength (PSI)	Wall Thickness (Inches)	Roof Thickness (Inches)
Region I	3000	23	18
	4000	20	16
	5000	18	14

TABLE 3.7-2A

Criteria A

DAMPING RATIOS USED IN ANALYSIS OF CATEGORY I STRUCTURES, SYSTEMS, AND COMPONENTS BY TVA

Item	Damping Ratio, Percent of Critical Viscous Damping		
	Operating Basis ~~1/2 Safe Shutdown~~ Earthquake	Safe Shutdown Earthquake	
Steel Containment Vessel	1	1	
Concrete Shield Building and Internal Concrete Structure	2	5	7*
Other Welded Steel Structures	2	2	5*
Bolted Steel Structures	5	5	7*
Other Reinforced Concrete Structures	5	5	7*
Bolted or Nailed Wooden Structures	7	7	10*
Damping for Determining Amplification through Soils for Soil-Supported Structures	10	10	
Vital Piping Systems**	0.5	1	

*Damping value used when stress levels are at or near yield.

**As an option, for some cases of piping response spectrum seismic analysis, variable damping of 5% to 10 hertz decreasing linearly to 2% at 20 hertz and remaining at 2% to 33 hertz was used for both 1/2 SSE and SSE as described in ASME Code Case N-411.

~~TABLE 3.7-28~~

Criteria B

NEW TABLE

DAMPING RATIOS USED IN ANALYSIS OF CATEGORY I STRUCTURES, SYSTEMS, AND COMPONENTS BY TVA

Item	Damping Ratio, Percent of Critical Viscous Damping	
	Operating Basis Earthquake	Safe Shutdown Earthquake
Steel Containment Vessel	2	4
Concrete Shield Building and Internal Concrete Structure	4	7
Other Welded Steel Structures	2	4
Bolted Steel Structures	4	7
Other Reinforced Concrete Structures	4	7
Damping for Determining Amplification through Soils for Soil-Supported Structures	(Strain dependent)	
* Piping system, all diameters greater than 12 inches	2	3
Other piping systems	1	2
Equipment	2	3

*As an option, for some cases of piping response spectrum seismic analysis, variable damping of 5% to 10 hertz decreasing linearly to 2% at 20 hertz and remaining at 2% to 33 hertz was used for both 1/2 SSE and SSE as described in ASME Code Case N-411.

TABLE 3.7-3

SUPPORTING MEDIA FOR CATEGORY I STRUCTURES

Rock-Supported Structures

Structures	Shear Wave Velocity of Bedrock, fps
Sheild Building	5900
Interior Concrete Structure	5900
Auxiliary-Control Building	5900
Steel Containment Vessel	5900
North Steam Valve Room	5900
ERCW Intake Pumping Station	

Soil-Supported Structures

Structure	Foundation Dimension, Ft.	Structure Height, Ft.	Imbedment Depth, Ft.	Overburden Depth, Ft.	Shear Wave Velocity FPS
Diesel Generator Building	120 x 95	42	10	35	1650
Waste-Packaging Area	42 x 84	43	1	30	1650
Refueling Water Storage Tank	43 Diameter	43	0	33	1008

Pile Supported Structures

Structure	Foundation Dimension, Ft.	Structure Height, Ft.	Imbedment Depth, Ft.	Overburden Depth, Ft.	Shear Wave Velocity FPS	No. Of Piles
Condensate Demineralizer Waste Evaporator Building	54 x 41	59	1	33	761	150
Additional Diesel Generator Building	53 X 96	32	12	33	1,000	154

Revised by Amendment 51

NEW

TABLE 3.7-23B

ADDITIONAL DIESEL GENERATOR BUILDING

ELEMENT PROPERTIES

$E_c = 720,000\ k/ft^2$ $G_c = 288,000\ k/ft^2$

Element No.	Length Ft	Area Ft^2	North-South Motion Moment of Inertia, Ft^4	North-South Motion Shear Factor	East-West Motion Moment of Inertia, Ft^4	East-West Motion Shear Factor
1	8.875	788.2	893,615.0	1.82	315,249.0	3.57
2	8.875	781.3	864,198.0	1.83	311,198.0	3.58
3	6.75	838.2	802,469.0	1.84	318,336.0	3.30
4	6.75	834.7	783,662.0	1.86	315,394.0	3.29

NEW

TABLE 3.7-23C

ADDITIONAL DIESEL GENERATOR BUILDING

MASS POINT PROPERTIES

Mass Point No.	Total Wt, Kips	Equipment Wt, Kips	Weight Moment of Inertia K-Ft^2 North-South Motion	Weight Moment of Inertia K-Ft^2 East-West Motion
1	8892.0	225	0.1034×10^8	0.3574×10^7
102	1043.0	0	0.120×10^7	0.4440×10^6
103	1820.0	50	0.1214×10^7	0.1043×10^7
104	910.0	0	0.8153×10^6	0.3337×10^6
105	1538.0	0	0.6527×10^6	0.8979×10^6

NEW

TABLE 3.7-23D

ADDITIONAL DIESEL GENERATOR BUILDING

NORMAL MODES OF VIBRATION

Mode No.	North-South Motion Frequency, Hz	East-West Motion Frequency, Hz
1		23.08
2	32.44	

Table

Table.

ADDITIONAL DIESEL-GENERATOR BUILDING

LOADS, LOADING COMBINATIONS, DEFINITIONS OF LOAD TERMS ___TED ______ DATE

CHECKED ______ DATE

Definition of Load Terms [redacted]

The following terms are used in the load combination equations for the [redacted] Additional Diesel Generator Building:

Normal loads, which are those loads to be encountered during normal plant operation and shutdown, include:

D - Dead loads or their related internal moments and forces including any permanent equipment loads; all hydrostatic loads; and earth loads applied to horizontal surfaces.

L - Live loads or their related internal moments and forces including any movable equipment loads and other loads which vary with intensity and occurrence, such as lateral soil pressures.

200 lb/ft^2 or equipment load (floors)
50 lb/ft^2 on roof

L_c - Construction live load = 50 lb/ft^2

T_o - Thermal effects and loads during normal operating or shutdown conditions, based on the most critical transient or steady-state condition.

R_o - Pipe reactions during normal operating or shutdown conditions, based on the most critical transient or steady-state condition.

Severe environmental loads include:

E - Loads generated by the OBE.

W - Loads generated by the design wind specified for the plant. See section 3.3 of FSAR.

Extreme environmental loads include:

E' - Load generated by the SSE.

F - Hydrostatic load from design basis flood.

W_t - Loads generated by the design tornado specified for the plant. Tornado loads include loads due to the tornado wind pressure, and to tornado-generated missiles.

Where:

$W_t = W_w$ (tornado wind) (see section 3.3 of FSAR).
$W_t = W_p$ (tornado pressure differential) (see Section 3.3 of FSAR)
$W_t = W_m$ (tornado missile, see table 3.5-17)
$W_t = W_w + .5 W_p$
$W_t = W_w + W_m$
$W_t = W_w + .5W_p + W_m$

COMPUTED ______ DATE ______

CHECKED ______ DATE ______

Load Combinations

Concrete Structures

a. For service load conditions, the strength design method was used and the following load combinations were considered.

1. $U = 1.4\ D + 1.7\ L$
2. $U = 1.4\ D + 1.7\ L + 1.9\ E$
3. $U = 1.4\ D + 1.7\ L + 1.7\ W$

If thermal stresses due to T_o and R_o are present, the following combinations were also considered.

1a. $U = (0.75)\ (1.4\ D + 1.7\ L + 1.7\ T_o + 1.7\ R_o)$
2a. $U = (0.75)\ (1.4\ D + 1.7\ L + 1.9\ E + 1.7\ T_o + 1.7\ R_o)$
3a. $U = (0.75)\ (1.4\ D + 1.7\ L + 1.7\ W + 1.7\ T_o + 1.7\ R_o)$

Both cases of L having its full value or being completely absent were checked. In addition, the following combinations were considered.

2a'. $U = 1.2\ D + 1.9\ E$
3a'. $U = 1.2\ D + 1.7\ W$

Where D or L reduce the effect of the loads given above, the corresponding coefficients were taken as 0.90 for D and zero for L. The vertical pressure of liquids was considered as dead load with due regard to variation in liquid depth.

b. For factored load conditions, which represent extreme environmental, abnormal, abnormal/severe environmental and abnormal/extreme environmental conditions, the strength design method was used and the following load combinations were considered.

4. $U = D + L + T_o + R_o + E'$
5. $U = D + L + T_o + R_o + W_t$

c. Other load conditions:

9. $U = 1.4\ D + 1.4\ L_c$
10. $U = D + L + F$

Steel Structures

a. For service load conditions, the elastic working stress design methods for Part 1 of the AISC specifications were used and the following load combinations were considered.

1. $S = D + L$
2. $S = D + L + E$
3. $S = D + L + W$

If thermal stresses due to T_o and R_o are present, the following combinations were also considered:

1a. $1.5S = D + L + T_o + R_o$
2a. $1.5S = D + L + T_o + R_o + E$
3a. $1.5S = D + L + T_o + R_o + W$

Both cases of L having its full value or being completely absent were checked.

b. For factored load conditions, the following load combinations were considered:

4. $1.6S = D + L + T_o + R_o + E'$
5. $1.6S = D + L + T_o + R_o + W_t$

In the above factored load combinations, thermal loads were neglected when it was shown that they are secondary and self-limiting in nature and where the material is ductile.

Uplift, Overturning, Sliding, and Flotation

Notation

The following terms were used in calculation of loads for uplift, overturning, sliding, and flotation:

D, E, W, E', W_t	As defined in section 2.1
H	Lateral earth pressure
F'	Buoyant force from design basis flood
F_b	Buoyant force from normal ground water

Requirements of Category I Structures

The following minimum factors apply for the load conditions given.

Load Combination	Minimum Factors of Safety: Overturning	Sliding	Flotation
D + H + E	1.5	1.5	---
D + H + W	1.5	1.5	---
D + H + E'	1.1	1.1	---
D + H + W_t	1.1	1.1	---
D + F'	---	---	1.1
D + F_b	---	---	1.5

TABLE 9.5-2

FAILURE MODE AND EFFECTS ANALYSIS

DIESEL FUEL OIL STORAGE AND TRANSFER SUBSYSTEM

Mode of Operation: 1-Hot Standby, 2-Startup, 3-Power Operation, 4-Normal Shutdown, 5-Emergency Shutdown, 6-Design Basis Event

Component	Function	*Mode of Oper. 1 2 3 4 5 6	Failure Mode	Method of Det.	Effect On Subsystem	Effect On System	Remarks
1. 7-Day supply tank	Fuel storage (68,000 gal)		Rupture	Low level alarm	Fail-Loss of fuel	None-Redundant subsystem	
2. Transfer pump	Transfer fuel from 7-day to day tank		Fail to run	None	None-Redundant pump	None-Redundnat subsystem	
			Fail to shutoff	High fuel oil level alarm on day tank	None-Overflow to 7-day tank	None-Redundant subsystem	
3. Check valve	Maintain fuel in suction line through pump when pump is stopped		Open	None	None	None-Redundant subsystem	
			Closed	None	None-Redundant pump and check valve	None-Redundant subsystem	
~~4. Solenoid valve~~	~~Selects day tank to receive fuel from 7-day tank~~		~~Open~~	~~High level alarm on day tank~~	~~None-Overflow to 7-day tank~~	~~None-Redundant subsystem~~	Delete
			~~Closed~~	~~Low level alarm on day tank~~	~~Fail-No fuel to day tank~~	~~None-Redundant subsystem~~	~~Valve has manual override to open valve in event power failure to solenoid~~
4 ~~5~~. Day tank 1	Fuel storage (550 gal)		Rupture	Low level alarm on day tank	Fail-No fuel	None-Redundant subsystem	
5 ~~6~~. Day tank 2	Fuel storage (550 gal)		Rupture	Low level alarm on day tank	Fail-No fuel	None-Redundant subsystem	

*Effects same for all modes of operation

Added by Amendment 33

TVA 11030 (WM-7-75)

NEW

Table 9.4-4A

~~FAILURE MODES AND EFFECTS ANALYSIS~~

ADDITIONAL DIESEL GENERATOR BUILDING.

Item	Function	Failure Mode	Effect on System	Effect on Plant	Remarks
1) AIR INTAKE ROOM	To channel incoming air flows into the add. diesel generator building supply air system	Blocked (Debris screen located in air intake structure)	Loss of ventilation to additional diesel generator room, fire protection room, 6.9kV board room, transformer room, and pipe gallery	NONE. The remaining diesel generator will be capable of providing adequate power to safely shut down the affected units	Possible loss of ADG's function until failure is repaired.
2) Motor-Operated Damper	To prevent backflow through the diesel generator room when the ventilation system is idle.	Closed (during normal operation)	same as item # 1	same as item # 1	Same as item # 1
		Open (during shutdown)	NONE	NONE	
3) ADG Space Heater	To maintain ADG room at or above 60°F during cold weather	No output (during cold weather)	NONE. Reduced ventilation air flows and remaining heater can maintain adequate temperatures (see item 4)	NONE	Heaters perform no safety-related function.
		Both Heaters fail	Reduced airflow from ventilation system can maintain adequate temperatures. (See ITEM 4)	NONE	Can result from loss of offsite power or seismic event. In these cases, D/G can be started to provide all necessary heating

TVA 11030 (WM-7-75)

NEW

Table 9.4-4A

~~FAILURE MODES AND EFFECTS ANALYSIS~~

ADDITIONAL DIESEL GENERATOR BUILDING.

Item	Function	Failure Mode	Effect on System	Effect on Plant	Remarks
4) Temperature sensor TS-30-332A,B TS-30-331A,B	To sense the temperature of air as it leaves the ADG room and to activate or deactivate fans as necessary to maintain required temperature	Low setpoint setting	Associated fan will operate continuously until manually turned off	NONE	space heaters will prevent excessive cooling during cold weather
		High setpoint setting	NONE. Second fan and its associated temperature sensor will provide necessary ventilation up to the maximum design outdoor air temperature of 97°F	NONE	
5) Exhaust fan	Air exhaust prime mover	No output	NONE. Second fan will provide necessary ventilation	NONE	Flow sensor will automatically start redundant fan
6) Isolation dampers FCO-30-332,-331	To prevent backflow through nonoperating fan	Open	NONE	NONE	
		Closed	NONE. Redundant fan	NONE	
7) Flow Sensor	Senses loss of air flow in duct	Higher than actual flow (while associated fan is operating)	NONE	NONE	
		Higher than actual flow (while associated fan is not operating)	Possible loss of ventilation	Same as item #1	Same as item #1
		Low	Redundant fan will be started unnecessarily	NONE	
8) Fire damper 0-30-618	To prevent a fire from penetrating the barrier between the air intake and fire protection room	Open (during a fire)	Fire may spread through ductwork	Same as item #1	Possible loss of ADG's function because of fire

VA 11030 (WM-7-75)

NEW

Table 9A-4A

~~FAILURE MODES AND EFFECTS ANALYSIS~~

ADDITIONAL DIESEL GENERATOR BUILDING.

Item	Function	Failure Mode	Effect on System	Effect on Plant	Remarks
8) CON'T		Closed (during normal operation)	Loss of ventilation to fire protection room	NONE. Non-safety related area	
9) Fire protection room space heater	To maintain fire protection room at or above 60°F during cold weather	No output (during cold weather)	NONE. Reduced ventilation airflows can maintain adequate temperatures	NONE. No safety-related equipment located in room.	Portable space heaters are available as a system backup. Also, heaters perform no safety-related function.
10) Fire damper 0-30-655 0-30-646 0-30-648	To prevent a fire from spreading into the transformer room	Open (during a fire)	Fire may spread through ductwork	Same as item # 1	Possible loss of ADG unit's function due to fire.
		Closed (during normal operation)		Same as item # 1	Same as Item # 1
11) Transformer room space heater	To maintain transformer room at or above 60°F during cold weather	No output (during cold weather)	NONE. Reduced ventilation airflows can maintain adequate temperatures	NONE	Portable space heaters are available as a system backup. Also, heaters perform no safety-related function.
12) Fire damper 0-30-651	To prevent a fire from penetrating the barrier between the transformer room and the air exhaust room.	Open (during a fire)	Fire may spread through ductwork	Same as item # 1	Possible loss of ADG unit's function due to fire. Also, see item # 1
		Closed (during normal operation)	Loss of ventilation to transformer room. Temperature may rise above [illegible]	Same as item # 1	Same as item # 1
13) Exhaust fan	Air exhaust prime mover	No output	Loss of ventilation to transformer and 6.9 kV board room	Same as item # 1	Same as item # 1

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Table 9.4-4A

~~FAILURE MODES AND EFFECTS ANALYSIS~~

ADDITIONAL DIESEL GENERATOR BUILDING.

Item	Function	Failure Mode	Effect on System	Effect on Plant	Remarks
) Isolation Damper CO-30-990	To prevent back-flow through non-operating fan.	Open	NONE	NONE	
		Closed	same as item # 13	Same as item # 13	same as item # 13
) Fire Damper -30-615	To prevent a fire from penetrating the barrier between the fire protection room and the 6.9 kV bd. room	Open (during a fire)	Fire may spread through ductwork	same as item # 1	same as item # 1
		Closed (during normal operation)	Loss of ventilation to 6.9 kV board room Heat may rise to an unacceptable temperature (≥104°F)	same as item # 1	Same as item # 1
6) 6.9 kV Board Ru Space Heater	To maintain board room temperatures at or above 60 °F during cold weather	No output (during cold weather)	NONE. Reduced ventilation air flows and remaining heater can maintain adequate temperatures	NONE	Heaters perform no safety-related function. Also, portable space heaters are available as a system backup.
		Both heaters fail	Reduced airflow from ventilation system can maintain acceptable temperature	NONE	Same as above
7) Fire damper 0-30-661 0-30-617	To prevent a fire from penetrating the barrier between the 6.9 kV bd room and the pipe gallery	Open (during a fire)	Fire may spread through ductwork.	Same as # 1	Same as # 1
		Closed (during normal operation)	Loss of ventilation to pipe gallery. Heat may rise to an [illegible] temperature (> 104°F)	Same as item # 1	Same as item # 1

SHEET OF

A 11030 (WM-7-75)

NEW Table 9.4-4A

~~FAILURE MODES AND EFFECTS ANALYSIS~~

ADDITIONAL DIESEL GENERATOR BUILDING.

Item	Function	Failure Mode	Effect on System	Effect on Plant	Remarks
18) Pipe Gallery Space Heater	To maintain Pipe Gallery temperatures at or above 60 °F during cold weather	No output (during cold weather)	NONE. Reduced ventilation air flows and remaining heater can maintain adequate temperature	NONE	Heaters perform no safety related function. Also, portable space heaters are available as a system backup
		Both heaters fail	Reduced air flow from ventilation system can maintain adequate temp.	NONE	Same as above.
20) 480V Bd Room Air Intake Vent	To channel supply air into the 480V board room	Blocked	Loss of board room ventilation. Temperature may rise above 104°F	Same as item # 1	Same as item # 1
21) 480V Bd Rm Space Heater	To maintain 480V Bd room at or above 60 °F during cold weather	No output (during cold weather)	Board room ventilation can be stopped to prevent bringing in cold outside air	NONE	Same as item # 16
22) Fire damper 0-30-652	To prevent a fire from penetrating the barrier between the 480V bd room and the air intake room	Open (during a fire)	Same as item # 15	Same as item # 1	Same as item # 1
		Closed (during normal operation)	Loss of ventilation to 480V board room. Temp may rise above 104°F	Same as item # 1	Same as item # 1
23) Fire damper 0-30-653	To prevent a fire from penetrating the barrier between the air intake room and the air exhaust room	Open (during a fire)	Same as item # 15.	Same as item # 1	Same as item # 1
		Closed (during normal operation)	Loss of exhaust air from 480V board room	Same as item # 1	Same as item # 1

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Table 9.4-4A
FAILURE MODES AND EFFECTS ANALYSIS
ADDITIONAL DIESEL GENERATOR BUILDING

Item	Function	Failure Mode	Effect on System	Effect on Plant	Remarks
24) 480V Board Room Exhaust Fan	Air exhaust prime mover	No output	Loss of board room ventilation. Temperature may rise above 104°F	same as item # 1	same as item # 1
25) Backdraft damper 0-30-662	To prevent backflow through nonoperating exhaust fan.	Open (when fan is not operating)	NONE	NONE	
		Closed (when fan is operating)	same as item # 24	same as item # 1	same as item # 1

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